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Innovation and the Evolution of Market Structure for Internet Access in the United States

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Abstract:

How and why did the U.S. commercial Internet access market structure evolve during its first decade? Commercial Internet access market structure arose from a propitious combination of inherited market structures from communications and computing, where a variety of firms already flourished and entrepreneurial norms prevailed. This setting nurtured innovative behavior across such key features as pricing, operational practices, and geographic coverage. Inherited regulatory decisions in communications markets had a nurturing effect on innovative activity. On-going regulatory decisions also shaped the market's evolution, sometimes nurturing innovation and sometimes not. This narrative and analysis informs conjectures about several unique features of U.S. market structure and innovative behavior. It also informs policy debates today about the role of regulation in nurturing or discouraging innovation behavior.

Outline

Introduction

How and why did the U.S. commercial Internet access market structure evolve during its first decade? Neither question has a ready answer. As the first country to commercialize the Internet, firms did not develop their businesses within a prescribed road map. Events that came after the National Science Foundation (NSF) privatized the Internet – such as the invention of World Wide Web and the commercial browser – created uncertainty about market value. In the midst of diffusion a major piece of legislation – the 1996 Telecommunications Act – altered many of the regulatory limits that shaped business decisions. Technological capabilities and business operations co-evolved as firms sought solutions to their business problems. Virtually all firms were open about their exploratory motives, taking a variety of approaches to commercialization, refining business practices as the environment changed and as they learned lessons from experience.

These efforts built a network that made the information of the online world available to participants nationwide for very low cost. After a decade, more than half of U.S. households were using the Internet (see figure 1), as were a greater fraction of business establishments. The access market alone generated revenues of over $23.4 billion in 2004[2], an impressive accomplishment since it does not include activities built on top of it, such as electronic retailing or auctions.

In this essay I describe the most salient features of market structure and analyze its evolution, focusing on developments in pricing, operational practices, and geographic coverage. One of my goals is to explain events in an accessible narrative – accessible, that is, to those who did not live through these complex events. A second goal is to further our understanding of how market structure shaped innovative behavior and visa versa.

I choose this latter emphasis for three reasons. First, it is appropriate for the era under scrutiny. During the first decade of the commercial Internet, many of the most basic facets of the commercial Internet were invented, tried in the market place, and refined. Second, it is rare to find such a rich and well-documented window into innovative behavior during the early years of a new market. These events will have value to scholars of young industries. Third, contemporary policy debates often mischaracterize the lessons for innovative behavior from recent events. These lessons still are relevant. To paraphrase Bruce Owen, the players have reached only the fifth inning of a nine-inning game and there is no rain delay in sight.[3]

This essay seeks to make the relationship between market structure and innovative behavior more central to writing about the history of the Internet. This emphasis amplifies the contributions of both successful and failed entrepreneurial firms, the lessons learned during competition between incumbent firms and innovative entrants, and the consequences of regulatory decisions for entrepreneurial activities. This emphasis is challenging to execute because of the genuine technical and regulatory complexity of events, which resist simplified narratives. It also is challenging due to the ensemble cast of participants in the Internet access market. Because they were drawn from disparate backgrounds, there was too much variety to define the innovation coming from a "typical" Internet access firm at any point in time, or, for that matter, over time.

Introduction – The Organization of the Narrative

I examine three time-frames, or "snapshots" of the market structure during the first decade, namely, 1993, 1998, and 2003. These snapshots capture salient features of each year, while allowing readers to perceive changes over time.

The first snapshot, in 1993, is – speaking loosely – just after the commercialization of Internet access in the United States. While later observers recognized the significance of this event, it hardly received notice at the time. The first advertised prices for commercial access appear in this year, mostly from descendents of NSFNet and not from the many other commercial firms who soon would have interests in the commercial network. Entrepreneurial firms explored the opportunity but only a few incumbent firms did. These exploratory actions eventually demonstrated the viability of the commercial market.

The second snapshot, in 1998, captures urgent investment in infrastructure markets to meet growing demand for Internet services. A clash of strategic visions and commercialization approaches reached its apex this year and the next. This clash takes place during the emergence of contracting norms and business practices that helped a large-scale network reach mass-market users with a wide variety of needs.

The third snapshot, in 2003, comes in the midst of a unique combination of economic triumph and hardship, amidst both stability and change. A second wave of investment in broadband began to cannibalize the services from firms that developed dial-up access. Investments in wireless access augmented the existing network, but a diversity of approaches clashed. These investments coincided with changes in the identities of leading firms.

Introduction – Market Structure, Innovation, and Variety

I will focus on a particular feature of competitive behavior, the variety of innovative commercial actions. Here "variety" means the following: firms use different commercial assets in different locations, different personnel with distinct sets of skills, different financial support structures with different milestones for measuring progress, and even different conceptual beliefs about the technical possibilities. As a result, one firm's assessment of the returns from innovating does not need to be the same as another's. Different assessments result in different methods for achieving the same commercial goals, which may lead to different costs, or different commercial goals altogether, such as targeting different customers.

Variety receives attention because it increases the possibilities for learning externalities across firms. Even in failure, one firm's innovation may fail, but in failing, teach lessons to others about what would succeed. In this sense, when a variety of firms flourishes the accumulated experience from all the firms can be greater than any individual firm could have or would have had on its own.

In this essay I will highlight that entrepreneurs played a key role in shaping the amount of variety, both because they supported many innovative commercial actions, and more importantly, because entrepreneurial firms pursued market opportunities *not* pursued by incumbent firms. Most remarkable, the variety continued to flourish through most of the first decade, even after some technical and commercial uncertainty declined.

How did this happen? An important part of the explanation highlights the commercial origins of the Internet. The commercial leaders of computing and communications did not forecast the growth of Internet access into a mass market service. Only a few entrepreneurial firms and descendents from the NSFNet offered service at the outset. In addition, a number of other Internet participants took foresighted actions to support the entrepreneurial firms that entered the commercial Internet access market. Many of these participants lacked profit motives or did not have the status of an established firm. As a result, this market lacked the typical business markers of the computing or communications markets, yet many entrepreneurs (and their financial backers) concluded that they had reasonable chance to profit from developing a new business. That surprised most incumbents in computing and communications, many of whom scrambled to react to a flood of entrepreneurial entrants.

Another part of the explanation emphasizes the resources devoted by firms to exploring a variety of potential contracting and operational routines, seeking to discover those that worked efficiently. These searches succeeded in developing low-cost and reliable operations for exchanging data and operating the Internet at a vast national scale. That raises questions about whether the emergence of routines enabled or deterred a variety of experiments. In this essay I will argue that the emergence of routines largely enhanced experimentation in this market for much of decade, especially in the second snapshot, in 1998. This remained so even later in the decade, in 2003, though with important qualifications. By then firms had incentives to pursue innovations that would be capital deepening, reinforcing pre-existing routines. In spite of that incentive, substitutes for existing services continued to emerge.

These conclusions will beg another question: What role did policy play in the Internet access market? Regulatory policies could have shaped many facets of Internet access markets because these markets involved telephone service and equipment, which are heavily regulated. A thorough answer, therefore, requires a close review of regulatory policy.

The narrative stresses that, while this market structure arose, in part, from several forward looking decisions at NSF, NSF's managers built on a propitious combination of inherited market structures and regulations from communications and computing markets. These regulations came into existence for historical reasons, only loosely connected to their eventual impact on exploratory behavior in Internet access markets. I highlight the importance of regulatory rules for pricing local telephone calls and changes to regulations supporting business-line restrictions at local telephone companies. On-going regulatory decisions also shaped the market's evolution, sometimes nurturing innovation and sometimes not. I highlight those regulatory decisions fostering or hindering diverse ownership over key assets such as backbone infrastructure, as well as those regarding the implementation of the 1996 Telecommunications Act. These decisions gave the U.S. Internet access industry several unique features in comparison to other countries.

While the essay largely focuses on how market structure shapes innovative action, I will also consider how innovative actions altered market structure. The relationship is not straightforward because innovative behavior, by itself, tends not to alter market structure in direct ways. Rather, innovative action leads to emergence of new ideas about services and business processes. In turn, this might induce new entry from entrepreneurial firms, which either contributes to altering the identities of leading firms, or induces incumbent firms to respond to

newly perceived opportunities or threats, inducing actions that alter the range of their services. These might or might not alter market structure.

More to the point, these changes are challenging to observe. New assessments about a market's potential, as well as the changes rendered, can be observed only with close study. To keep the discussion focused, I will limit the scope of my study to changes in pricing, operational practices, and expanded geographic scope. I will show how these changed in response to innovative actions that led to a new understanding about sources of market value.

These conclusions differ from prior work mostly in emphasis. To date, scholars of Internet infrastructure have focused on factors shaping the digital divide[4], the dot-com boom or the policies for broadband investment.[5] While there is considerable analysis of specific regulatory rules, no research has traced the patterns of interplay between regulation, market structure, and exploratory behavior over the first decade. This omission should be rectified. Exploratory behavior and entrepreneurship are key ingredients in economic development and growth, and do not happen by accident. Some settings encourage them, while others discourage them, and the difference fades with time as observers forget what actually happened and what might have happened under different circumstances.

I also will touch upon themes of interest to those studying Internet use across countries. While the essay does not discuss the origins of the market structure in other countries, it does inform conjectures about why U.S. market structure and firm behavior was unique. For example, contemporary news accounts noted several unique features of the U.S. access market. The United States contained several thousand retail access providers, while no country other than Canada contained more than a few. Related, the U.S. firms also were the first to introduce flat-rate pricing for Internet access, while firms in many other countries never did.[6]

1993 – A Nascent Internet Access Market

The administrators at the NSF did not privatize the Internet with the intent of starting a boom in exploratory investment in Internet infrastructure markets. They privatized the Internet in response to concerns that seem parochial to later observers, concerns such as whether or not a federal agency could operate and fund the NSFNet as it grew larger. Privatization also allowed nonacademic vendors to sell Internet access to private users without violating government "acceptable use" policies, thereby ending a simmering dispute that would have boiled over.[7]

To ensure that the Internet would continue to support researchers and universities, the NSF implemented a privatization plan with many far-sighted features designed to enable growth. This included removal of government funding and management of Internet backbone assets, designing institutions for regional (non-governmental) funding of data-exchange points, and bidding out the allocation of domain names to a private firm. Yet, most information technology (IT) users outside of universities did not react to the NSF's actions. Most IT users and managers of commercial vendors acted as if nothing of any commercial significance had occurred.

That "non-reaction" would persist for a couple years. In that setting, entrepreneurial firms with views outside the mainstream had incentives to make risky and exploratory investments, which, as it turned out, were sufficient to induce many to take action. Their initial commercial success catalyzed a confrontation between different approaches to the commercial opportunity in Internet access markets.

1993a – Internet Connectivity In and Outside the Academy

The collection of firms that operated the Internet in 1993 together formed a propitious combination of firms. While pursuing their own interests, most of these firms simultaneously cooperated with one another. The cooperation at this stage established precedents for operating a commercial network. Such operations were crucial to enabling firms to explore the commercial Internet over the next few years.

Internet Service Providers (ISPs) require a physical connection because of the architecture of the Internet. Both under the academic and commercial network (as shown in figure 2), the structure of the Internet is organized as a hierarchical tree. Each layer of connectivity is dependent on the following layer. The lowest level of the Internet is the customer's computer, which is connected to the Internet through a local ISP. An ISP maintains its own sub-network, connecting its POPs (points of presence) and servers with IP (Internet Protocol) networks. These local access providers, or ISPs, get their connectivity to the wider Internet from other providers upstream, either regional or national ISPs. Regional networks connect directly to the national backbone providers.[8] Prior to 1992, private backbone providers connected to public backbones at network access points. This arrangement raised awkward questions about growing a commercial service, which could have (and, under any plausible scenario, would have) involved using public assets to carry private commercial traffic. That is,

commercial traffic might go over the public backbone, violating the NSF's policies forbidding use of public assets for commercial purposes.

The academic ISP was an informal operation in many universities, but it resembled what would soon become a commercial ISP at the technical and operational level. The academic ISP maintained modem banks and servers, administered passwords for logins, and some also maintained a local area network at the university. Unlike a commercial ISP, however, the academic ISP did not charge its users for access.[9] Many also did not monitor user time on-line, a practice that some commercial firms would adopt for billing purposes.

The NSF had subsidized the establishment of academic ISPs throughout the United States, but rarely their operations. In most locations, university ISPs operated with a mix of professional managers and students. Many of the complementary network operations, such as the management of routing tables, data-exchange facilities and the Internet backbone, were set up by the NSF or, more precisely, by the firms with whom NSF subcontracted, such as MERIT Networks Incorporated, IBM (International Business Machines),and MCI (Microwave Communications, Inc.) and ANS (Advanced Network Services).[10] These firms and groups continued to operate after privatization, funded within a regional structure. A few intrepid ISPs and data carriers then took actions that the NSF's managers had anticipated, namely, planning to offer commercial Internet access to users who were not affiliated with a university.[11] Most of these vendors were offspring of the NSFNet, such as IBM, MCI, ANS (Advanced Network Services), and PSI (Performance Systems International), among others.

Overall, descendents of the NSFNet began 1993 with a set of clients and customers and had plans to attract more, fostered by the NSF's plans to privatize the network. It is hard to believe in retrospect, but this collection of firms did not receive much attention from contemporaries, except a few professional insiders. No prominent business magazine hailed these firms as leaders of an Internet revolution (as was done to the founders of Netscape a only two years later). Their business prospects were not deemed unusually strong. That would all change once they demonstrated the commercial viability of the Internet access market to later market participants. Related, many of their key managerial decisions stayed within a fairly small professional community. Only later did observers realize that they had established precedents for cooperation for data exchange, defining the role of a private firm and the operations for the entire network.

NSF's managers encouraged participation from a variety of firms during the privatization of the Internet, setting up a structure that had multiple firms in positions of leadership – for example, more than MCI and IBM were involved from the outset. Unlike many other countries, which handed management of the Internet over to their telephone company, nothing in the US prevented many firms from participating in the operations as the network grew. That outcome had two economic underpinnings that were obvious to contemporaries but easy to overlook in retrospect. At the time the communication industry's structure was in flux, still unsettled due to on-going court hearings over the Judge Harold Greene's administration of the Modified Final Judgment. It would have been foolish for NSF to rely on a single firm for all services, such as AT&T, who was not the only firm offering data communications services. At the time, there were at least three firms with national fiber networks, AT&T, MCI and Sprint, but many others appeared to have the ability and resources to plausibly develop national networks too – though, to be sure, that is not equivalent to saying they had a business case for doing so. Second, NSF's managers and researchers were an important user of the Internet and anticipated continuing. When users design their own industries, they have incentives to invite multiple suppliers and encourage innovative behavior from multiple firms. Implementing this in practice is easier said than done, but, in this case, the academic Internet already had multiple participants. It had established technical and procedural precedents for moving data between the servers in different organizations.

1993b – The Imminent Surprise

To a knowledgeable insider in 1993, the Internet was still progressing, but it received no attention outside a very small technically-oriented community. The earliest advertisements for ISPs in *Boardwatch Magazine* appear in late 1993, as the magazine attempted to expand from its role as the primary news publication for the bulletin board marketplace. As it turned out, advertisements grew slowly until mid-1995, at which point the operation became so large that *Boardwatch* began to organize its presentation in table format.[12]

Although the Internet access market was considered a good growth opportunity for the descendents of the NSFNet, for a number of reasons discussed below it was not considered a huge immediate market opportunity, as it ultimately turned out to be. E-mail was popular among experienced users, so it was easy to forecast that growth in such activity could generate steady revenues for the firms providing the infrastructure.

Understand this potential in context: Many market participants had anticipated some form of mass market electronic commerce for households. Online service providers, such as CompuServe, Prodigy, Genie, and AOL (America On-Line), continued to try to grow the home market for online information in a bulletin board format. These services had difficulty widening their appeal beyond technically sophisticated home PC users, however, though they were trying. In addition, Microsoft Network, or MSN, made ambitious plans for a proprietary network with features similar to AOL's, but the plans called for a gradual development cycle over several years, anticipating that the mass-market opportunity for MSN would emerge slowly, giving them enough time to learn from their experience and improve.[13]

In 1993, the conversion of large-scale computing to client-server architecture or any other form of networking was the *revolution-du-jour* among IT consultants and others in the market of enterprise computing. According to the standard mantra, the Internet contributed to that movement in some useful ways, since exchanging data between computing systems was cumbersome in other formats, such as EDI. Most of the consulting practices in this area did not forecast the large impact the Internet would have on enterprise computing.

A couple foresighted contrarian investors made moves in 1993 and 1994, but no major change in investing occurred until 1995 – and even then, the boom did not occur until a few months prior to (and then especially after) the Netscape initial public offering (IPO) in August, 1995.[14] The first high-profile analysis of the Internet access market on Wall Street did not arrive until Mary Meeker at Morgan Stanley organized one, which resulted in a publication for general audiences in 1996, a bit later after her team had done related work for clients.[15]

In other words, with few exceptions, firms with strong interests in Internet infrastructure markets did not take actions in 1993 that would have served their interests a few years later. Like the abundant clues about impending disaster in a B-movie, later observers could easily see many symptoms of the coming surprise that few of the contemporaries noticed or prepared for.

1993c – Phone Companies, Bulletin Boards, and Policy

In 1993, local telephone firms and bulletin board operators already had an uneasy and asymmetric relationship with one another, defined by years of lawsuits, regulatory disputes, and distinct attitudes about technology and operations. This relationship arose for reasons idiosyncratic to the United States (and Canada); and for a short time, these two types of firms formed an unlikely partnership in providing Internet access to the United States. Hence, this

relationship defines many facets of the unique features of the U.S. experience in comparison to other countries.[16]

Local telephone firms were compelled by regulators to do two things that helped bulletin board operators. First, state regulators in virtually every state required unmeasured pricing for local telephone calls over short distances, such as a ten- to fifteen-mile radius (or more in rural areas). Local calls involved extremely low costs per minute, if any. This regulation arose out of policies designed to encourage universal service in telephone use. More to the point, such rules were not motivated by the consequences for bulletin board business, though they had huge consequences for them.

Second, the Federal Communications Commission (FCC) compelled local telephone companies not to "discriminate" against bulletin boards, as well as any others that were classified as "enhanced service providers." These complex regulations grew out of years of antitrust and regulatory lawsuits and inquiries at the FCC. They resulted in a series of regulatory rulings for communications equipment and services provided by the phone company and those who interacted with it. The set of regulations became known as Computers I, II, and III. By 1993 only Computers II and III were in effect.[17] Computer II was issued in 1980, and viewed as an improvement to Computer I, an inquiry that began in 1966, resulting in an order in 1971. The first Computer III order was issued in 1986, and underwent subsequent revision and court challenges. These would eventually shape Internet use, access, and business in profound ways, though, as one can see from the timing of their adoption, they had motivations other than their impact on the Internet.

Computer II offered protection for entrants into new information service markets from post-entry discriminatory behavior from telephone companies. It permitted telephone firms to enter these same markets only if the telephone firm contained a structurally separate division offering services that competed with new entrants. Telephone firms were compelled by this order to offer any service to a competitor that it would offer to its own division. By the time the Internet was commercializing, the FCC was in the midst of trying to write (and rewrite) Computer III, which was designed to be less burdensome but accomplish similar goals as Computer II and was in the midst of court challenge. Under Computer III a telephone company could have an integrated division as long as it also had a very detailed and approved plan for providing interconnection to others. More to the point, by the early 1990s, every local telephone firm lived

with rules that required it to treat a competitor the same as its own division, and these applied to bulletin board operators.

These rules had motivations other than their impact on the Internet. They arose from several tendencies in U.S. law and regulation. First, U.S. antitrust law enforcement agencies have a long history of attempting to carry out antitrust rulings. These prevent a dominant incumbent from using its dominance in one market (i.e., local telephone service) for commercial gain in another where competitive entry and innovative activity might emerge (e.g., selling data). A second set of concerns arose out of the tradition of common carrier law, which requires monopoly carriers not to use its monopoly to the benefit of one business partner but not another, i.e., not to discriminate against any potential business partner.[18]

These rules were regarded as a nuisance for local telephone firm operations in the details, but the broad principles were widely appreciated by 1993. As a technical matter, any such engineering details behind interconnection had long ago been worked out.[19] More concretely, the timing and features of calls to bulletin boards looked distinct from voice calls, placing peculiar demands on capacity during peak load times. They were also a small source of revenue, since they led users to demand second lines. Overall, because the bulletin board volumes were comparatively small in relation to voice telephony, most local telephone firms and local regulators thought the burdens were a manageable nuisance.

Why did this matter? Because ISPs would absorb the regulatory norms from the bulletin board industry. Unlike the experience in much of the rest of the world, when the Internet privatized, neither U.S. telephone company executives nor regulators assumed that the telephone companies should be the only provider of Internet service. Nor, for that matter, did users, who did not resist the idea of calling another party to make their Internet service operable. In brief, ISPs were free to explore the commercial possibilities without much constraint on their actions, protected by the ample precedents, especially as they were embodied in Computers II and III.

To be sure, these rules were *the most* important business parameters for bulletin board operators and academic ISPs. A bulletin board operator attempted to locate its modem banks at phone numbers close to where its customer base could make a local phone call. Once these investments were made, a bulletin board operator could not alter its networks or change advertising about its coverage without accruing cost. Many bulletin board operators also believed the telephone companies would not be cooperative without being compelled to do so – whether this belief was true or not is another question. Many also believed they would not have a viable

business unless telephone companies were precluded from being in their market space, though there was no legal basis for excluding telephone firms who complied with either Computers II or III.

Three types of bulletin board operators emerged in the 1980s and early 1990s. Most would transition into the Internet market as they learned about its potential. The first were the online service providers, such as AOL, Prodigy, and Compuserve, as already mentioned. These firms all had ambitious management and all would attempt to become national ISPs a few years later as Internet demand boomed, with varying degrees of success. Of the three types of bulletin board operators, only the online service providers tended to have any experience in political or regulatory arenas.

The second set of bulletin board operators resembled the first group in technical operations, but tended to be smaller because the organization attempted to accomplish a special function, such as product support or sales (e.g., information sales or product manuals) or club support (e.g., airplane hobbyists) or games (e.g., groups devoted to Dungeons and Dragons). Some provided limited user-group functions, such as daily updates of news, organized Usenet group postings, or periodic email. Some of these did become ISPs later.[20] Unlike the academic ISPs, many of these firms were at home with commercial behavior and, as the Internet diffused, quietly transformed themselves into content providers or hosting sites. This group also produced some leaders of amateur groups and industry associations. Importantly, the descendents from this group had perspectives that differed from the NSF descendents, from the on-line service providers, and because they were present in many cities nationwide, from technology business leaders in places like Silicon Valley, New York and Boston.

The third type of operator, and arguably the most numerous, was the operator who supported pornography. Though any individual firm tended to be small, these operators were present in every city in the United States, even with quite small populations.[21] Once again, many of these operators were comfortable with commercial practices the NSFNet descendents did not practice. The pornographers were social pariahs in many cities, protected under the First Amendment, and defended by such groups as the ACLU (American Civil Liberties Union) in light of the perceived larger principles. Many of them would become ISPs, and most would become content providers and hosting sites when the Internet developed.

Overall, these firms seeded the newly privatized Internet with a myriad of commercial experiments. After the Internet privatized, there was no single typical response from these firms.

They had widely different backgrounds. They did not speak with a single voice on any of the key questions regarding forecasting, strategy, or public policy. The backgrounds and experiences of these firms differed from those that descended from NSFNet, giving them distinct viewpoints about the commercial potential of the Internet. Some, especially the smaller firms, were most comfortable casting themselves as outsiders, adopting the attitude that they were "Net-heads", in contrast to the "Bell-heads" who did not perceive the Internet on the same terms.[22] Many sought to satisfy local needs or niche customers they perceived the large national firms ignored. Others, such as AOL or MSN, viewed the phone companies as cooperative partners in some respects, and intended to use the federal regulatory apparatus to settle disputes.

1993d –Commercial Platforms in Computing

Did many firms in the computing and communications markets know what would be coming in the next few years? By elementary reasoning the answer is No. If they had seen it coming, they would have acted differently in 1993. They would have invested heavily in anticipation of a coming boom.

There is more to that observation than just private regret. This nonaction later shaped the industry's development in two ways. First, entrepreneurs with so-called contrarian views had incentives to look for opportunities in Internet access markets because no established firm had an insurmountable competitive advantage founded on early-mover actions. Second, because entrepreneurs succeeded in exploiting the lack of prior investment by incumbents, existing platforms for communications and computing did not exert much early influence over the direction of technical change.

One early mover was Cisco, a supplier of routers and hubs for academic ISPs and operations. In 1993, the company went through a restructuring and change in management, guided by its venture capitalists and board of directors. At this point, the new managers for the company adopted a strategy to expand beyond just hubs and routers, positioning Cisco as the leading Internet equipment supplier. As perception about the growth potential of the Internet market changed, so did Cisco's tactics, such as accelerating its acquisitions; but the company's ambition to "become the lead architect and provider for TCP/IP voice, data, and video," as all its company material states, remained unchanged from 1993 onward. In retrospect, it is apparent that Cisco's early repositioning was rare. Most equipment firms took partial steps towards strong positions in server markets, such as Nortel, Novell, Alcatel, or 3Com, but did not make such overt

changes in strategy as early as Cisco. The equipment division of AT&T, which would become Lucent in a few years, also did not make any such declarations about the Internet.

IBM and MCI both offer interesting contrasts. Both firms held unique positions as descendents from the NSFNet. Both took actions to support their provision of data-carrier services. In IBM's case this was enhanced by the change in strategic direction when Gerstner took over as CEO. In 1993 he and many others regarded the organization as in the midst of a severe business crisis, so it is hard to know just how much of this was a defensive reorganization and how much was forward looking strategies to take advantage of prior experiments with the Internet.[23] In retrospect, it appears that the changes initiated in 1993 made it easier for IBM's later transition into serving the booming commercial Internet markets as an ISP for business and as a service integrator for enterprises using the Internet.

In MCI's case, their experience with NSFNet left them well positioned for offering services in two rather distinct markets. First, they had developed skills they could translate into a business for national data transport over their own fiber network. Second, they could offer ISP service for both home and business in the coming commercial data market, even though they did not have an identity as an old-line computer firm. As it turned out, as the demand for Internet services boomed, MCI did gain a large amount of business in both, though especially the former.

It has also been widely noted that most firms in the software industry did not anticipate the Internet. Very few existing software firms initiated new projects in 1993 related to the Internet, and almost none were founded this early.[24] Specifically, Microsoft's inattention to the Internet later received a spotlight in its federal antitrust trial. Consequently, the publicly available documents reveal the foundations for Microsoft's inattention: Namely, because Microsoft's strategists studied the actions of many others firms before settling on its plans, Microsoft's actions reflected the consensus of views elsewhere across the country, thus illustrating the types of forecasting errors made elsewhere at the time.

In 1993, Microsoft was in the midst of developing a product that later would be called Windows 95. Windows 95 was supposed to replace DOS (disk operating system) as the standard OS (operating system) in PCs (personal computers). Up to that point, Windows was an application built on top of DOS. The architects of Windows 95 were confident that the main competitive issues affiliated with the Internet *had* been addressed. Reading TCP/IP compatible files had been a standard feature of Unix systems for some time, an operating system with which Microsoft anticipated competing in server markets. Making Windows 95 TCP/IP compatible,

both in the PC and in the server versions,[25] Microsoft anticipated that Internet applications would be built on top of the OS by others. Microsoft did not, however, anticipate any other application would be pervasive—except e-mail, for which it had designed an application that would, in fact, become popular in a few years.

Predicting that it would need a platform to engage in the widely anticipated developments in electronic commerce, Microsoft's strategists concluded that only a proprietary network could be profitable and the applications for it *could not* be built on nonproprietary technical standards, such as those that supported the Internet. Hence, Microsoft anticipated that its new MSN division would use proprietary standards and other Microsoft-specific designs, and they anticipated borrowing lessons learned from the actions of firms such as CompuServe and AOL.

There was never any *technical* error in these assessments, a statement that some naïve contemporaries made about Microsoft's decisions. The strategy team had up-to-date technical information and sufficient technical skill to understand how these technologies functioned. Rather, the "error" was one of misinterpreting commercial prospects. This error would take four interrelated forms: (1) anticipating much less commercial activity around the Internet than what occurred, (2) mis-underestimating the Internet's value to users, (3) underestimating the ability of Internet firms to support applications that threatened Microsoft's profitability in the marketplace, and (4) the late recognition of the first three errors. The first three errors were common to many firms and only the fourth error of timing was unique to Microsoft—the top strategists did not recognize the first three errors until the spring of 1995.[26] That was later than many other firms who begun to investigate these issues in the late fall of 1994, around Netscape's founding.

By the spring of 1995, when Microsoft eventually decided to change its commercial priorities about the Internet, it had already made a number of decisions that would limit its short term ability to follow through on this new priority. For example, while the designers of Windows 95 could change some aspects of the design quickly, business partners could not. The first browsers in Windows 95 was not designed to support HTML (Hyper Text Markup Language), so, as a result, software application firms in 1995 and 1996 had to use tools and solutions from available shareware—such as those available from the World Wide Web Consortium—and from other firms that had correctly anticipated the need to support HTML, such as Netscape. Such behavior ran counter to Microsoft's strategic goal to be the indispensable supporter of all major tools for application development on the PC operating system.[27]

1993e – Nurturing Institutions

If established firms did not support application development by entrepreneurs in the early years, what institutions arose to aid exploration? The research community acted partly as the breeding ground for organizations that would later foster standard protocols for many applications. Their actions would kick-start private development by making it much easier for a small firm to begin commercial life without becoming beholden to the commercial interests of an established firm. Because this institutional setting looked so different from any precedent, most observers did not forecast its importance at the outset.

Unlike many new industries, the Internet did not begin its early commercial life beholden to the technical or commercial vision of a single dominant firm that (perhaps) held a key patent or dominant market position. In addition, NSF received no explicit Congressional directives on key issues (such as which suppliers to favor), so NSF's managers had discretion to do what they thought would work best.[28]

The University of Illinois' National Center for SuperComputing Applications, a well-funded operation subsidized by NSF, would play an unexpected role in the history of all commercial Internet firms. Joining the large community of programmers employed there, a few computer science undergraduates were hired to create a browser to make use of Tim Berners-Lee's HTML language, which was a 1989 creation. That project resulted in the Mosaic Browser, which became available in November of 1993, just *after* the Internet privatized. It was downloaded by millions over the next 18 months, primarily users in research labs and universities, the primary users of the Internet at the time. More important, its invention and diffusion were not anticipated by the NSF's administrators. While the University of Illinois arranged to license the Mosaic browser to others, the same students went on to found Netscape Corporation with Jim Clark in late 1994.

NSF managers also did not foresee the dilemma concerning the management of the domain name system—one of the Internet's earliest and most visible policy dilemmas, which had informal institutional arrangements until the early 1990s. In 1992 the NSF put the registry function out for bid. It was apparent even then that there was no sense in frequently altering management of the registry database after privatization, a feature that implied registries required some sort of regulatory oversight as a quasi-natural monopoly; however, the NSF had not put in

place an oversight system for registries. To be fair, the unanticipated growth in the Internet would have made institutional design extremely challenging; even if a regulatory framework had been put in place early, the mission would have had to change dramatically and quickly.

In response to the perceived need, and after much growth in the Internet, in 1997-98 the Clinton administration set up ICANN (Internet Corporation for Assigned Names and Numbers) under the domain of the Department of Commerce. This birth was contentious and those difficulties made for good copy among Internet insiders.[29] By this point, however, most of the valuable domain names already were allocated (e.g., CNN owned CNN.com and so on) and an active secondary market for domain names had emerged for many of the other names, some of which were still quite valuable. It was not a blindingly efficient system, but it allowed Internet access firms to get many things done in due time.

Again, unlike most new industries, the Internet access market was founded with several of the institutions normally found in a *mature* market, such as an industry association and a set of standing active committees to consider upgrading interoperability standards. For example, many of the other important, though perhaps less well-known, technological building blocks for commercial ISPs came from the Internet research communities that had long used and refined them. Unix compatibility with TCP/IP had long been a DOD procurement requirement, and, as a result, all vendors for commercial Unix operating systems had built in compatibility as a matter of routine, obviating the need to alter most private server software as the Internet diffused. Other building blocks included e-mail (i.e., the send mail shareware), FTP (file-transfer-protocol), Kerberos (security), and the basic protocols to make TCP/IP data work in Unix-based systems. As it would turn out, many of these building blocks became a part of the suite of protocols and standards endorsed by the World Wide Web Consortium, founded by Berners-Lee in October 1994, who located his office at the Massachusetts Institute of Technology.[30]

This was not the only such organization to play a related role. Several organizations helped coordinate developments of the Internet when it was under Defense Advanced Research Projects Agency (DARPA) and NSF management. The Internet Engineering Task Force (IETF), among others, had played a role at DARPA as part of the Internet Activities Board (IAB). The IETF had become the focal organization for protocol development and technical concerns as privatization approached, folding in efforts that had been spread among several groups until then. With privatization, the Internet Society, a nonprofit organization, took formal control over the IETF and IAB, complementing both groups with additional information-dissemination tasks. The

IETF continued to accept proposals for national standards and protocol development, operating like an industry consortium for standard setting.[31]

Another example of a vendor group supporting the young industry was the Commercial Internet Exchange (CIX). It was founded in 1991 by several early ISPs to facilitate the operation of data exchange, both inside and eventually outside the public access points.[32] It went on to become an organization that all the ISPs joined in the early years. Playing the role of an access industry trade association during the mid 1990s, CIX facilitated conversation among members and policy platforms for Washington, D.C. lawmakers, agencies, and their staff.

Open Source projects also made a difference. These were building on another precursor institution that also continued to play a role: shareware distributed over BBSs and with floppy disk libraries, and, increasingly, over the Internet. The Linux movement had already begun prior to 1993, but it was not an important player in commercial Internet markets for a few years, except in so far as it was a model of how to successfully organize such a community of developers. Perhaps more directly essential to the growth of the commercial Internet was a project begun by a set of programmers in 1995—Apache. It would become the typical server software for ISPs; again, it was another outgrowth of the experience in the shareware communities.

Overall, most of the leading incumbent firms in computing had not taken action in anticipation of the Internet. As a result, none of the usual technical support activity existed. Yet, that did not hinder private development of the Internet, as would happen in most young industries. A number of descendents from the research communities attempted to serve a similar function in the area of interoperability standards, languages, and basic tools for managing access at the access firms. Much of this was an outgrowth of the cooperative behavior supporting the decentralized Internet in the research communities. In 1993, there was still the larger open question of whether this would be sufficient to support growth of the commercial Internet.

1993 – Overview

In retrospect, the hand-off of a technology from public management to privatization had several features whose importance was hard to forecast. First, there were the Internet's unusual origins and the unusual institutions that accompanied that history. Second, the NSF's managers planned for a large scale of operations in e-mail. As it turned out, many of these plans could accommodate a different set of applications that it had not anticipated, built on the World Wide Web. Third, the timing of key discoveries fostered surprise, reducing the possibility for

anticipatory investment by established firms and leaving ample commercial room for multiple entrants.

The structure of the marketplace and the regulatory rules that governed the Internet access market at this point played to the advantages of venture-funded entrepreneurial firms. The commercial setting contained an unusual set of unprecedented features, and most incumbent firms were not investing in anticipation of large growth. An eclectic mix of economic actors made investments while exploring the possibilities for building viable businesses. They generated experiences that, in turn, would provide lessons that others would notice soon. Soon the Internet access business would grow unexpectedly fast, initiating a competitive contest between entrepreneurial firms and with established firms.

1998 – An Era of Impatience

By 1998, the U.S. Internet access market had experienced the benefits and frenzy of commercial entry unconstrained by a single commercial vision. Firms with distinct views about the commercial prospects for the Internet tried to build businesses to support their views about the source of value. Those views reflected different local knowledge bases about customer needs, different visions about how to commercialize a national service, and distinct strategies for taking advantage of existing assets. New retail pricing practices also changed under competitive pressure. In addition, there was no contemporary consensus about where or how the competition would end.

The growth in demand for the Internet justified enormous investments by both users and vendors. To accommodate this change in the scale, national operators instituted a set of pricing policies for governing commercial transactions in the backbone for Internet access. The ISPs with ambitions to sell mass-market service also instituted regular policies for their service. Both actions were part of a general movement toward the (almost) inexorable use of a small number of standardized technical processes for routine tasks to operate the network.

1998a – The Emergence of Routine Network Operations

A large-scale national network involving so many participants could not operate efficiently without standard modes of contracting. Almost from the outset of commercialization, many of the largest firms began to insist on them at both the wholesale (e.g., backbone) and retail

(e.g., ISP) level. After some changes coincident with the diffusion of the browser, regular and predictable patterns of contracting emerged, and, in tandem, a sense of routine to this collective activity also began to emerge. Any individual firm could take for granted this routine when it made its own parochial decisions. In this sense, the routines affiliated with the market in 1998 shaped the character of exploratory activity by all firms.

Regular operations had to accommodate an extensive variety of demands. Most households physically connected through dial-up service, though both cable and DSL technologies gained some use among households near the end of the millennium.[33] Broadband connections were more typical for businesses in major cities, if they were anywhere, but ISPs in some areas tried to sell T-1 lines or ISDN (Integrated Services Digital Network), as did some local phone companies. Many large business users made the physical connection through leased lines or other direct connections, while smaller users often tended to have dial-in connections, if they had any at all.

There were several different types of ISPs by 1998. The national private backbone providers (i.e., MCI, Sprint, etc.) were the largest carriers of data, and many of these firms also provided retail ISP services to consumers or other ISPs who rented rights to resell use of their modem banks. The remaining ISPs ranged in size and scale from wholesale regional firms down to the local ISP handling a small number of dial-in customers. Many of the large firms were familiar incumbents, such as Earthlink, Sprint, AT&T, IBM Global Network, AOL, and Mindspring. Other large firms included entrants or Internet insiders from NSF, such as PSINet, Netcom, ANS (Advanced Network Services), and GTE (General Telephone and Electronics, which acquired assets from BBN [Bolt Beranek and Newman] Planet in 1997) and others. Some of these firms owned their own fiber (e.g., MCI) and some of them ran their backbones on fiber rented from others (e.g., UUNet). Still others offered ISP services to consumers (e.g., AOL and MSN), but did not own any facilities. They rented it from others (e.g., ANS), though users did not know this and often did not care as long as everything worked.

Market share at the retail level was skewed. A couple dozen of the largest firms accounted for 75% of market share nationally and a couple hundred for 90% of market share. In other words, the majority of these ISPs were small dial-ups covering a small regional area, but the majority of users employed national providers.[34]

The so-called Mom and Pop ISPs reflected their small size and informal origins—in contrast with national firms, such as AT&T WorldNet. In August 1996, *Boardwatch* listed prices

for 2,934 ISPs; in February 1997 for 3,535; in January 1998 for 4,167; and in January 1999 for 4,511. In each case, though, the magazine listed many more ISPs for whom they did not have price information. The highest reported number in *Boardwatch* was just over 7,000 in March 2000.[35] As another illustration of the variety of ISPs available, one estimate found over sixty-five thousand phone numbers used by just over 6,000 ISPs in the fall of 1998.[36] A national firm would support anywhere from four to six hundred phone numbers. Half of these ISPs supported only one phone number, which means there were about 3,000 ISPs supporting one phone number, and the rest supporting anywhere from two to six hundred numbers.

Many small ISPs ran their own network POPs and provided limited geographic coverage. Many also leased such lines or externally managed POPs through a third party, such as AT&T or MCI, in locations where they did not have coverage. This allowed them to offer national phone numbers to their local customers, competing with commercial online services with national coverage.

How did anyone get a sense of order out of such heterogeneity? To the delight of some market participants and the dismay of others, by 1998 a commercial structure had emerged that some called *tiered*.[37] Tiers indicated which firms carried data over long distances and collected charges from others for transit service. The size of footprint, the volume of traffic, and the propitious location of one firm's lines determined the *direction* of charges from one firm to another. More important, this was a commercial mechanism that involved private interchange of data and revenues, funding operations in a way other than what NSF envisioned. It grew up next to the regional data exchange points set up at the beginning of commercialization.

The largest national backbone firms all became tier-1 providers. This included AT&T, IBM (before being sold to AT&T), MCI (whose backbone was sold to Cable and Wireless as a condition for the merger with WorldCom), ANS (who received many of its facilities from AOL), UUNet (eventually sold to WorldCom), and Sprint, among others.[38] Most regional and local ISPs became lower-tier ISPs, purchasing interconnection from either one of several national providers or from a larger regional provider, which then passed on the traffic to the tier-1 firms.

Nobody doubted the existence of tiers, but others observers were skeptical of the rigidity of tiers. They called this system a *mesh*,[39] where participants faced many options for interconnection. For example, many ISPs arranged to use multiple backbone providers (known as multi-homing), thereby diminishing the market power of any one backbone provider in any single location. Similarly, dial-up ISPs with large networks could receive calls in one location but back-

haul them to another location to be connected to the Internet. This network design gave ISPs multiple options for connecting to the Internet, thereby limiting the discriminatory power of any single backbone firm. Finally, many of the largest national firms acted in ways that contributed to the mesh. Using a contract form known as Indefatigable Right of Use (IRU),[40] some firms rented their facilities for twenty years to other firms that needed connections along a particular path (e.g., from one city to another). Some firms also rented lists of phone numbers at different locations to retail ISPs that wanted to offer their traveling customers local phone numbers to call in different cities.

The organization of transit services in the United States overlapped with the tier designation. Backbone firms that exchanged traffic of roughly equal size adopted practices that facilitated trade, that is, they did not charge each other. This practice was just equivalent to volume discounting for the sake of saving costs on monitoring traffic and billing one another; however, it has other consequences as well. The practice raised the incentives of the major backbone firms to exchange traffic bilaterally, bypassing the public exchanges. Private interchange raised issues about the quality of data services for those who used the public exchange. While both practices generated inquiries at the FCC, nothing substantively was done about either one.[41]

By 1998, a number of other routine technical and business processes had begun to characterize the operations of ISPs.[42] There was no consensus about the set of services or operations that led to the greatest profitability in the long run. In light of such uncertainty, many ISPs sought to differentiate themselves from each other by offering additional services, such as hosting, Web development, network services, and high-speed access [43] These services were in addition to e-mail, newsgroup service, or easy access to portal content, online account management, customer service, technical support, Internet training, and file space.

Overall, this situation had both routine and variety. Routines fostered efficient operations, especially in the exchange of data between firms. Their emergence facilitated low-cost commercial experimentation by Internet access firms, which were growing rapidly at the time and attempting to serve a perceived (and anticipated) growth in demand.

1998b – Growing the New Mass-Market Internet.

In 1998, an Internet user could surf thousands of sites from an extraordinary variety of sources and could participate in the Web-equivalent of news, magazine, and hobby clubs.

Shopping also changed for both mass market and niche items. Every mass-market item was available, such as books, CDs, tickets, computing equipment, mattresses, or pet food. Pornography was widely available and accounted for a portion of traffic. Users could also purchase specialty items, such as goat cheese from a remote farm in Wisconsin, a monarch chrysalis from a Caribbean butterfly farm, and hundreds of thousands of other products that specialized vendors were trying to sell. It was unbelievable, exciting, and overwhelming.[44]

Helping new users navigate these possibilities became a facet of the Internet access business. Some firms specialized in profiting from selling to new users. For example, building on its business philosophy—which it developed prior to the Internet's diffusion—AOL developed simple instructions and online help, as well as services specialized for new users, such as community sites and easy-to-use e-mail. By the end of 1998 (and for a variety of reasons discussed below), AOL had grown into the dominant national provider to the home, with a market share between 40% and 50%, depending on who was counting and when.[45]

Most of the online service providers—Prodigy, Genie, CompuServe, MSN, and AOL—had also begun converting to Internet service in 1995, each with different results. Except for AOL, all failed to gain much additional market share from this move. Several savvy decisions contributed to AOL's success. For example, in 1996, AOL sold off its physical facilities, relying on a long-term contract with another firm that operated the modem bank. It chose to concentrate its investments on content software development and marketing. It successfully made the transition to unlimited pricing at about the same time.

In addition, AOL's version of Instant Messaging became the dominant provider by far, especially after it bought ICQ (an acronym for "I-Seek-You"), an entrepreneurial firm that filed for several patents and that, after entering in 1996, had established the largest Instant Messaging network on the Internet.[46] After establishing dominance in this application, AOL went to great lengths to prevent others from interoperating with its system without paying licensing fees. In face, some smaller ISPs did pay licensing revenues to AOL to allow its users to interoperate. However, that was not uniformly true. In 1998, AOL, Yahoo, and MSN all supported their own Instant Messaging applications and these could not interoperate with one another.

One of the most important business decisions occurred in early spring of 1996, when AOL agreed to make Internet Explorer its default browser in exchange for two things: (1) several hundred millions dollars in cash and (2) Microsoft lifting its contract restrictions that prohibited AOL from putting its logo on a PC's first screen. This deal went into effect in the summer and

fall of 1996, when Internet Explorer 3.0 was rolled out, and had huge consequence throughout 1997 for the browser wars with Netscape, especially after Explorer 4.0 was released. Along with other factors, it allowed Microsoft to win the browser wars definitively. It also gave AOL a marketing tool that no firm other than MSN had. That, and large investments in marketing to new users, allowed AOL to grow quite rapidly.[47]

Finally, in February1998, AOL bought CompuServe, a merger that many observers criticized, since it seemed to combine a firm that focused on technical users with one that did not. In retrospect, it solidified AOL's leadership of dial-up service for the next several years.[48]

The loyalty of AOL's user base earned AOL users contempt from technically oriented and experienced Internet users, who were comfortable using online resources without anyone's aid. America On-Line's approach became known as a *walled garden*, for the way in which AOL protected or (in the words of critics) spoon fed content to its users. Yet, AOL was not the only firm pursuing such actions. MSN also became known for behavior that catered to new users. So too did @home, as well as Juno, Earthlink and Mindspring, Netzero and a few national firms.

As of 1998, AOL's success suggested that a large number of new users preferred their approach, but the success of others suggested that a large number preferred something else, such as the many mom-and-pop ISPs who accommodated local community needs. There were predictions that the Internet access business would bifurcate around these two approaches. There also were contrasting predictions that new users would become more sophisticated and depart AOL in time, while others forecast AOL would add new services to keep such customers.

Accordingly, the scope of service continued to differ among ISPs, with no emergence of a norm for what constituted minimal or maximal service in an ISP that was not AOL. Some ISPs offered simple service for low prices, depending on users to make do with Yahoo!, Excite, Lycos, or other portals. Other ISPs offered many additional services, charging for some of these services and bundling other services into standard contracts. Private-label ISPs emerged when associations and affiliation groups offered rebranded Internet access to their members. These groups did not operate an ISP; instead, their access was being repackaged from the provider that supplied the connection.

For business users there were many options. By 1998, many local telephone firms had begun basic service. For instance, the long distance and data carrier, AT&T, emerged as the largest retail Internet provider to businesses; AT&T had already had a data carrier business with firms, but it grew larger when IBM sold the company its operation in 1997. Likewise,

WorldCom was not far behind AT&T, having acquired UUNet and MFS (Metropolitan Fiber Service).

When MCI and UUNET became part of WorldCom in 1998, WorldCom became the largest backbone provider and a large reseller of national POPs to other firms. The so-called fringe backbone players were not trivial players, however. Sprint, AT&T, and GTE also had large networks, collocated with their existing networks. In addition, Level3 had raised considerable funds and announced plans to enter at a national scale with a newly configured architecture, so the long term structure of supply did not appear set or stable.

The retail market also still appeared to be open to recent entrants, such as Erols, Earthlink, Mindspring, Main One, Verio, and many others. All these firms gained large market positions, but plenty of smaller firms also had acquired enough market share to sustain themselves. The so-called free ISP model also emerged in late 1998 and grew rapidly in 1999, offering free Internet access in exchange for advertisements placed on the users' screen. These firms eventually signed up several million households, generally for use of a second account.

The growth in ISPs led to a growth in Internet calls, which, in turn, increased demand for second lines, a source of revenue for local telephone firms.[49] This market had become too large for any telephone firm to ignore. By 1998 most local telephone companies also had entered the dial-up ISP business.

In summary, growing the mass market placed new demands on Internet access firms. Many ISPs took actions to serve this growing market; many did not, choosing instead to limit their focus on technically sophisticated users, on niche users in a small locale, or on users learning at their own expense. This variety reflected a lack of consensus about which approach was superior for offering ISP service.

1998c – The Geographic Coverage of Access Providers[50]

The massive Internet investments after 1995 gave rise to two geographic features: widespread geographic availability of access and "overbuilding" in some places. These outcomes did not have to be connected, since the former referred to the spread of retail access while the latter generally referred to the investment in fiber for backbone to provide transport services. However, these were linked in one sense: the spread of backbone fiber helped retail ISPs flourish in some places.

Internet access became widespread for a several reasons. First, it lent itself to small-scale customization at the user's location. It was easy to adapt to PC use or available local area network technology.[51] Second and related, economies of scale did not arise, since ISPs could survive on a small scale. Third, the standard technical software for supporting an ISP, Apache, was widely available, and the necessary technical know-how for getting started did not differ greatly from routine knowledge found at a firm performing computing services prior to commercialization. Fourth, the growth of standardized contracting practices for renting facilities from other firms in other locations added to the geographic reach of individual ISPs, even in areas where they did not operate facilities.

By 1998, many ISPs had located in all the major population centers, but there were also some providers in sparsely populated rural areas. One estimate showed that more than ninety-two percent of the U.S. population had access by a local phone call to seven or more ISPs by 1998. Less than five percent did not have any access.[52] Almost certainly, these estimates are conservative. The true percentage of the population without access to a competitive dial-up market is much lower than five percent.

The spread of firms, such as those operated by Akamai or Digital Island, contributed to the geographic spread of Internet access. These firms operated cache servers in multiple locations, often co-locating with data-carriers. They would offer up-dated "mirrors" of the most frequently accessed sites, so users could receive data quickly, rather than from a central server operated by, say, AOL or Yahoo!. Popular Web sites, such as Yahoo!, made deals with these firms which then eliminated much of the competitive differences between locations of backbones and thus removed differences in qualities of performance for users.

The only locations lacking Internet access were the poorest of urban areas or the smallest and most remote rural populations. Some of this small minority of the country was in areas that bore signs of permanent retardation of development.[53] The rural areas often lacked competitive supply of providers, and even when suppliers existed, they sometimes provided limited services or focused on specific segments, such as business users.[54] There was never any issue about getting some service, even in the worse situation. A user could make a long-distance phone call and get service, but the effective cost was higher.

In addition, there was a dichotomy between the growth patterns of entrepreneurial firms that became national and those that became regional. National firms grew by starting with major cities across the country and then progressively moving to cities of smaller populations. Firms

with a regional focus grew into geographically contiguous areas, seemingly irrespective of urban or rural features. By 1998, many rural telephone cooperatives were opening Internet service—following long-standing traditions in small and rural cities to use collective quasi-public organizations to provide utility services that other private firms did not find profitable.

The vast majority of the coverage in rural areas came from local firms. In 1996, the providers in rural counties with a population under 50,000 were overwhelmingly local or regional. Only in populations of 50,000 or above, did national firms begin to appear. In the fall of 1998, the equivalent figures were 30,000 or lower, which indicates that some national firms had moved into slightly smaller areas and less dense geographic locations. Figures 3 and 4 provide a visual sense of those patterns in 1996 and 1998.[55]

Whereas the massive geographic spread of Internet access availability evolved from both national and regional firms, concerns about overbuilding focused on the concentration of national backbone fiber in major urban areas. Some of these firms owned facilities, i.e., national fiber optic networks. Other firms built their backbone services, using IRUs they arranged with the owners of fiber. Some of these firms only offered transit services to other ISPs, while others also offered sets of phone numbers in some locations and rented them to other ISPs. In these two senses, the overbuilding of backbone in major urban areas contributed to the availability of Internet access at the retail level, either by making transit services more available (and presumably cheaper) or by making POPs available to others to rent.

Interest in this situation must be put in context. In many industries, observers *would not* find it surprising that different ambitious firms would attempt to serve the same customer in the same capacity. Yet, no such behavior had ever been seen within a large-scale communications service market. And this break with precedent was the source of astonishment.

Several factors simultaneously led to the overbuilding. For one, the U.S. backbone was built in increments by many firms, not by a single firm with monopoly ownership. In the late 1990s, notably AT&T, Sprint, WorldCom, GTE, Level3, Qwest, Global Crossing, Cable and Wireless, and Williams all had plans to build networks with national geographic footprints, that is, presence in all or most major cities.[56] These plans were not coordinated.

Also, the impatient financial environment of the late 1990s provided four related incentives to grow. The first was due to Wall Street's exuberance, as stock prices for publicly traded firms responded to announcements of building plans. Initial public offerings for new Internet ventures also displayed a similar pattern. This generated backbone investments by many

of the participants as well as investments to support retail ISP service in many locations, even when it resulted in significant redundancies between rival suppliers.

Second, there was a common perception among ISPs that demand for Internet traffic would grow quickly for many years. In retrospect, it is hard distinguish between the reality, hyperbole, and dreams that underpinned this perception about demand. This perception also fostered the next factor, aggressive supplier behavior.

Third, there was a common understanding that savvy business practices required laying backbone capacity (i.e., sinking fiber-optics into the ground) ahead of buyers' demand. Backbone suppliers saw themselves racing with each other to sign (what at the time was forecast to be) lucrative contracts for services with low-variable operating expenses. This view led firms to sign up retail customers at a financial loss at that time, with the belief that because users would not want to switch later, i.e., firms were supporting reliable well-paying revenue streams in the future.

Fourth, many backbone firms anticipated reselling capacity. Such resale also generated incentives to build capacity early for resale later (as long as demand continued to grow). Indeed, firms such as UUNet were ready buyers of such capacity for a time, running their network over such fiber.

This incautious behavior fostered uncoordinated build-outs among rival firms in the same locations, which, in turn, fostered overlapping footprints and other redundancies in supply. By 1998, it was becoming apparent that commercial firms replicated potential capacity along similar paths. Locations such as San Francisco, Chicago, Los Angeles, Washington DC, and New York (among others) benefited from this redundancy, because every firm with a national footprint thought it had to be in such centrally located major cities. At the time much of this fiber along these routes remained "unlit", which was industry parlance for unused.

The situation might be summarized simply: At the time there were plenty of demand for data services and well publicized predictions about the growth in demand. Along with other factors, these predictions motivated investment, though these predictions would turn out to be too optimistic. There were also predictions about anticipated increases in the efficiencies of transmission technology. These predictions played little role in investment behavior, and, even if these were expected, they came to realization faster than most investors and their advisors expected. So, as it would turn out, not enough growth in demand and too much growth in supply

would put pressure on prices and, only a couple years later, make it challenging for investors to realize high returns on their investments.[57] This is discussed more below.

1998d – Pricing Practices

By 1998 the dominant price point for all dial-up ISPs was twenty dollars a month. Survey data showed that it was truly modal among actual purchases. That said, there was considerable variance around this price point, with roughly one-third of households paying less and one-third paying more.[58] How did twenty dollars a month arise as a focal contract?

To begin with, this price point represented a dramatic change from the pricing norms governing bulletin boards, where the pricing structure of the majority of services involved a subscription charge (on a monthly or yearly basis) *and* an hourly fee for usage. For many applications, users could get online for "bursts" of time, which would reduce the total size of usage fees. The emergence of faster cheaper modems and large scale modem banks with lower per-port costs opened the possibility for a different pricing norm, one that did not minimize the time users spend on the telephone communicating with a server. The emergence of low cost routines for accessing a massive number of phone lines was complementary, because it enabled many ISPs to set up modem banks at a scale only rarely seen during the bulletin board era.

As the ISP industry began to develop, users demonstrated preferences for unmonitored browsing behavior, which translated into resistance to contractual limits on their time spent online. In response, some vendors began offering unlimited usage for a fixed monthly price. These plans are commonly referred to as *flat-rate* or *unlimited* plans.

As with any proposal changing existing practices, this proposal was not initially obvious to many vendors. Even if some users liked flat-rate pricing, there were questions about whether new users could adapt to old norms. Moreover, ISPs easily could see the difficulties of managing the modem line loads over the day or week, especially during peak time. Peak load issues would cause ISPs to invest more in modem equipment, so this type of contract was perceived to be costly to support.

A key event for the development of this focal price was the entry of AT&T's Worldnet service, which was first aimed at business in late 1995 and then explicitly marketed at households in early 1996. Far from being the first ISP to offer home service (PSINet and Netcom, among many others, could legitimately claim to have developed large-scale customer bases sooner), AT&T was among the first to offer service from a branded and established national company.

The sole exception, IBM, supported a world-wide business service but not the mass-market home user.

Initially, AT&T's entry went well. Choosing twenty dollars a month with the intent of becoming the dominant national provider of household Internet service, AT&T acquired over one million users within a year. That choice also imposed pricing pressure on other ISPs throughout the country.

But a funny thing happened on the way to dominance. Many small ISPs reacted, and AT&T Worldnet did not achieve dominance. More precisely, the number of new users grew so quickly that plenty of other new firms also could compete for their business. Said simply, AT&T grew large and fast, but so did others.

When AOL converted fully to flat-rate pricing in 1996, it experienced a difficult transition. Although AOL also adopted a price at near twenty dollars a month, its management had not anticipated its users' enthusiastic response to flat-rate pricing: There were insufficient modem banks nationwide to handle the increasing traffic, and many users experienced busy signals. The bad publicity induced further entry by other ISPs looking to acquire customers fleeing the busy phone lines. Ultimately, AOL survived the bad publicity through a series of new investments in facilities, content, and intense marketing, as well as several savvy deals, such as those with ICQ, Microsoft and CompuServe.[59]

Eventually, many ISPs in 1996 and 1997 introduced plans that looked like a twenty-dollar-per-month fee, but many were not (actually). The fine print in these contracts included hourly limits and high marginal pricing above the limit. Most such limits were not particularly binding (i.e., involving monthly limits ranging from sixty to one hundred hours) unless the user remained online for hours at a time most days of the month.[60]

One pricing pattern had emerged by 1998 and it would continue for the next few years: Namely, ISPs were largely unable to raise prices as the Internet improved. Many ISPs improved their own service in myriad ways, as did many complementors. For example, most ISPs had adopted technologies to enable Web pages to upload more quickly, either by improving dynamic Web page allocation through caching or by making arrangements with Akamai for its service. In addition, browsers got better (as a result of the browser wars and as a result of learning), so every users experience improved. In addition, those providing help services were experienced and knew how to resolve issues. Yet, such improvements were part of the standard package rather than vehicles for premium pricing. Take, for example, the upgrade from 28K to 56K modems. There

were two price levels for a short time—with a higher premium for faster modem service, but by late 1998, the twenty-dollar price umbrella prevailed once again.[61] In other words, the primary gate-keepers for access did not capture a higher fraction of the value from improvements in the network's many components.

Remarkably, the opposite trend for pricing also did not emerge: prices did not fall to the floor in spite of some tremendous drops in transmission costs. From 1996 to 1999 prices for non-AOL dial-up services showed a small and steady decline downward, while AOL's did not decline at all. General estimates are hard to come by, but the declines each year were no more (on average) than a reduction in a dollar for a monthly contract.[62] Several factors contributed to price buoyancy, but the key seemed to be user-inertia and loyalty. Many ISPs saw no reason to reduce prices if user were reluctant to give up email addresses or other services to which they had grown accustomed. Accordingly, many ISPs adopted policies refusing to forward email for former customers, as a way to make them reluctant to switch ISPs. Indeed, the largest ISP in 1998, AOL, gave many of the same reasons for not lowering its prices.

1998e – Public Policies

The NSF's privatization did not come with any quid-pro-quo about how ISPs implemented technologies. Aside from the loosely coordinated use of a few de facto standards—coming from groups such as the World Wide Web consortium, the EITF or the IEEE (Institute of Electrical and Electronics Engineers)—mandates after commercialization were fairly minimal.[63] The ISPs were able to tailor their offerings to local market conditions.

As with other investments, impatience was a key motivation for the decision to adopt new technology.[64] Policy could play a useful role in such an environment, up to a point. For example, to avoid interference with existing equipment, the FCC imposed a number of technical restrictions on the design of 56K modems, as it had with prior transmission technologies, such as ISDN. When the International Telecommunications Union intervened in the 56K modem war and designed a new standard, adoption was voluntary; but participants decided to adopt the standard because they foresaw a huge potential loss if they delayed the upgrade further. In other words, policy helped design a better standard from a technical standpoint, and publicly supported institutions helped firms not let competitive rivalry interfere with an upgrade that was in everyone's interest.

The most important policy issues arose from the implementation of the recently passed 1996 Telecom Act. This was the first major piece of federal legislation for telecommunications since the 1934 Act that established the FCC. While the 1996 Telecom Act contained many complex features, several deserve attention here because of their affect on exploratory behavior.

Some parts of the 1996 Act attempted to establish regulatory continuity. For example, it re-affirmed FCC policies to define ISPs as providers of enhanced services, following precedents set in Computers I, II and III. Courts reaffirmed such an interpretation. For all the reasons discussed above, this had the short term effect of encouraging entry of ISPs.

Related, ISPs did not face obligations to pay the universal service fees that telephone companies had to. The Act also exempted cable companies, which— because of the asymmetric burden placed on telephone companies—became especially important to regulators when cable companies began converting their lines for carrying Internet traffic to homes. However, this situation festered for several years. Its resolution could have involved one of two actions, imposing universal service fees on Internet access provided by cable firms or removing these fees for the suppliers of DSL (principally provided by telephone companies and third parties). Through a rather circuitous route and after several years of debate the US tended towards the latter choice. To understand how, we need to describe other features of the Act.

The Act formalized legal definitions for Competitive Local Exchange Companies (CLECs). Though CLECs bore some resemblance to Competitive Access Providers of the recent past, this definition did represent a legal discontinuity.[65] The new definition was embedded in a broad set of provisions governing the access of CLECs to facilities from Incumbent Local Exchange Companies, or ILECs. These provisions were intended to further competitive local telephony. As it turned out, the activities of CLECs presented an acute and immediate issue for the intersection of U.S. telephone and Internet policy. Specifically, although some CLECs built their own facilities, some rented facilities from ILECs. As directed by the Act, state and federal regulators had set prices for renting elements of the ILEC's network, such as the loops that carried DSL (digital subscriber line). A related set of policies concerned the billing and compensation of CLECs for exchanging traffic with ILECs. In brief, the national billing system for telephony assumed that interconnecting firms made as many calls as they received. In the U.S. compensation system, a firm paid for only one of these—the calls made, not those received.

In other words, if a CLEC received about as many calls as they sent, then no issue would have arisen. While some CLECs did just that, not all did, which gave rise to a particularly urgent

question for regulators. Taking advantage of the inter-carrier rules, a number of CLECs set up businesses to *receive* ISP calls from households but *send* very few, which effectively billed other telephone companies for "reciprocal compensation."

Initially, this strategy went unnoticed by regulators, and consequently, regulatory decisions for reciprocal compensation of CLECs encouraged CLEC entry, which partly encouraged ISP entry through interconnection with CLECs. The practice received attention as it grew, resulting in hearings at the FCC in 1998. The FCC passed a set of rules to do away with the practice in February 1999.[66]

Although these billing strategies and subsequent policy decisions had effects, the effects should not be exaggerated. Their scale grew between 1997 and 1998, but ISP entry started well before then and continued afterwards (until the dot-com bust in the spring of 2000). Moreover, most of the effect was felt in urban areas: Such locations would have had a great deal of ISP entry even without this implicit subsidy to CLECs.

Though this was the first attempt by FCC staff to interpret the Act's principles and ambiguities, it ending the de facto assumption of forbearance from intervening in entrepreneurial events in enhanced service markets, a precedent Computers II, and III had attempted to establish. To be fair, later some intervention was not a choice for FCC commissioners, as court decisions and Congressional pressure also compelled the FCC to revisit specific actions.

The Act also contained provisions for the "E-rate program"— a provision with both real and symbolic significance. Among other goals, the E-rate program was aimed at alleviating inequities in the provision of the Internet and was proposed as a funding scheme for bringing the Internet to disadvantaged users, particularly at schools and libraries. Closely identified with the ambitions of Vice President Al Gore, who had made fostering next-generation information technology a special interest, the E-rate program was labeled the "Gore Tax" by opponents. It survived several court challenges and regulatory lobbying efforts after its passage. Although delayed by the legal challenges, the E-rate program eventually raised over two billion dollars a year from long-distance telephone bills. This money was administered by the FCC. In 1998, this program was just getting under way. It would eventually have an impact, especially on isolated locations.

In one other sense, the Internet access market got an additional implicit and explicit subsidy. The Internet Tax Freedom Act, passed in October 1998, placed a federal moratorium on taxing the provision of Internet access. Unlike several other communications technologies, such

as cellular telephony or land-line telephony, Internet access was free from local attempts to tax the service (except those that were grandfathered in prior to October 1, 1998). The market's young status justified the law, according to supporters, who worried that excessive local taxation could deter growth for the new nationwide commercial applications of electronic commerce.[67]

There was some confusion about the scope of the Internet Tax Freedom Act. Some observers incorrectly thought it outlawed sales taxes on electronic commerce. Actually, other laws already determined that retailing e-commerce had to be treated as equivalent to a catalogue or mail-order seller. On-line entities were not subject to local sales taxes as long as the transactions crossed state lines, which they did—for all intent and purposes—if the firms that sold the goods maintained no active physical organization in the state.

Finally, 1998 saw the beginning of a policy debate about merger policy for telecommunications. The 1996 Telecommunication Act did not include any overt guidance about merger policy in the telephone industry. Yet, merger policy had a large effect on the restructuring of access markets. Domain for merger policy in the United States rests with the Department of Justice (DOJ) and the Federal Trade Commission (FTC), as well as with the FCC when the merger involves a national telephone firm.

During the Clinton administration, several high-profile mergers met with opposition. For example, the divestiture of some Internet backbone became a condition for government approval of the MCI WorldCom merger, a condition that appears to have been a significant action in retrospect, as it helped to partially deconcentrate ownership of those assets. Similarly, opposition to the proposed merger between Sprint and WorldCom, which the European regulators were the first to oppose and which the DOJ almost certainly would have opposed too, at least in part (the merger was called off before official DOJ action), looks wise in retrospect in light of WorldCom's later troubles. Finally, in late 1998, Bell Atlantic proposed a merger with GTE (forming Verizon). As condition for approval, GTE spun off the backbone as a separate entity (forming Genuity). These actions encouraged less concentrated ownership in a setting where the number of decision makers was small.

In the local telephone market, in contrast, merger policy was comparatively focused on fostering competition in voice telephony—specifically, encouraging one telephone company to open its facilities to entrants and to enter the geographic territory of another, as envisioned by Section 271 of the 1996 Act.[68] The consequences for the growing Internet were secondary. In this sense, the Clinton administration did not place restrictions on several mergers involving local

telephone companies, but used merger as a quid-pro-quo for conditions that shaped entry by one voice firm into another's territory or facilitated entry by CLECs the ILEC opposed.

Overall, policies during this period encouraged exploratory behavior among young firms. This can be seen in both the fiscal rules that minimized taxation and fostered technical advance among young firms and the FCC's forbearance in enhanced service markets, which preserved the regulatory umbrella for ISPs. It also can be seen in the intervention in merger cases—actions that partially fostered less concentration in backbone markets and partly not. Policy, however, did not speak with one voice, and there were limits to forbearance. By 1998, the FCC began to intervene in inter-carrier compensation issues, taking actions to protect incumbent compensation.

1998 – Overview

In just half a decade, firms built a functioning network that made the information of the online world available to many participants for very low cost. Indeed, the whole of the Internet access industry was greater than the sum of individual firm's efforts, both on an operational level and in terms of its exploratory activity. A set of routines began to emerge, and so did a variety of approaches to delivery of service. The Internet access business grew quickly and it became pervasively available in every major location. Different firms perceived different customer needs, employed different visions about the commercial possibilities, and invested in assets at an unprecedented level, even for the computer market.

At a broad level, such a combination of expansion in sales, variety in approaches, and increasing standardization in operations, was not unusual for a young entrepreneurial market. Yet, to contemporaries the specific accomplishments appeared remarkable. No operating large-scale communication network had ever been so entrepreneurial and expanded so fast, except, arguably, the new and competitive U.S. telephone industry a century earlier. The situation in 1998 is all the more remarkable compared to 2003, when a patina of stability informed a great deal of activity.

2003 – Reliability and New Transitions

By 2003, the quality of the average Internet user experience had increased visibly, some of it due to increased reliability of ISPs and backbone firms, and some of it due to improvements

in complementary services, such as cache sites. Accordingly, the average number of hours online and the amount of data traffic had increased too. In addition, the access market became swept up in the broad forces altering the commercial Internet, such as the dot-com bust (i.e., the financial bankruptcy of many new Internet businesses), which diminished investor enthusiasm for this sector. Widespread availability of backbone diminished long-haul prices and created further financial hardship at any firm vested in the national backbone. These factors and others altered the identities of commercial leaders who had shaped prior growth in the access market.

Though many standard operations for many large-scale activities emerged, innovative activity had not ceased. Two additional modes for access had emerged, here labeled *broadband* and *wireless*. Although the arrival of broadband and wireless access had been expected for some time, the perceived slowness of its buildout shaped a national debate about broadband policies.

2003a – The Emergence of Broadband

After the Internet demonstrated its potential to become a mass-market service, the value of upgrading to broadband—where users experienced higher access speeds—was anticipated by nearly every market vendor, user, and policymaker. In an earlier era, broadband was associated with upgrading the telephone network to support ISDN, which achieved speeds of 128K. These initiatives had not generated widespread adoption. In contrast, broadband of the new era had a few key features. First, it was always-on, which meant a user could gain access to the Internet nearly instantaneously once a session began, in contrast to dial-up. Second, it had larger bandwidth than dial-up or ISDN. Third, and probably most important, a whole slew of software applications had already been written for slower lines and would improve on faster lines. As a result, many users had the motivation to pay for an upgrade, which, in turn, motivated vendors to invest to meet the anticipated demand. To put it simply, in the absence of that content, it is not obvious the user had such motives. Hence, its presence reduced the commercial uncertainty affiliated with developing broadband services – in comparison to a decade or even a half decade earlier.

Broadband Internet access firms took three forms. First, many business firms could acquire direct access in the form of T-1 lines from telephone firms or from CLECS. This had been true well before 2003, though this was normally observed only in business districts. By 2003, T-1 lines had low market share due to their costs and the demand for this form was in decline. Local telephone companies largely dominated this market in their home areas.

Competitive provision had also arisen in some major cities in the form of metropolitan rings of fiber, which appeared to be the likely form for providing future direct access to business.[69]

Second, cable television firms retrofitted their lines and switches to carry Internet data, usually with much faster bandwidth to the user than from the user. This kind of broadband access had the earliest build-out, partly due to the regulatory advantages that will be discussed subsequently. Its market share was highest in 2003.[70] This involved a small number of (mostly national) firms, with Comcast (having acquired the cable assets of AT&T in late 2002), Time-Warner, Charter, and Cox serving the largest number of households. By 2003, these firms had taken complete control of their Internet service, ending five years of outsourcing software development and other aspects of ISP service to @home.[71]

Third, local telephone firms upgraded their lines and switches to carry DSL, usually with an ADSL (Asymmetric Digital Subscriber Line) implementation, which, once again, was faster at sending data to the user than from the user. The actual bandwidth of these modes varied with implementation and location, but, generally, peak DSL had higher bandwidth than dial-up, but not as high as cable.[72] By 2003, few CLECs remained in this market, and those that did so, only did so with the protection of regulator-enforced agreements with ILECs. As a result, local telephone firms largely dominated supply of DSL.[73]

In the earliest years of diffusion to households—that is, prior to 2003—supply-side issues were the main determinants of Internet availability. Cable firms and telephone firms needed to retrofit existing plants, and that constrained availability in many places. Cable companies and telephone companies found highly dense areas less costly due to economies of scale in distribution and lower expenses in build-out.

Digital Subscriber Line access was inhibited for some consumers due to the infrastructure and distance requirements. The maximum coverage radius for DSL is approximately 18,000 feet from a central switching office (CO), which is a large, expensive building.[74] Furthermore, the radius is closer to 12,000 feet for high-quality, low-interruption service. Therefore, those living outside this radius from the COs already built before DSL was available were more likely to suffer from lack of service.

The crucial factors that affected the decision to offer DSL or cable were similar: (1) the cost of supplying the service across different densities, (2) the potential size of the market, (3) the cost of reaching the Internet backbone, and (4) telephone company regulations.[75]

As of October 2003, 37.2% of Internet users (i.e., just under 20% of U.S. households) possessed high-speed connection. Broadband penetration was uneven, however: because 41.2% of urban and 41.6% of central city households with Internet access used broadband, whereas only 25.3% of rural households did. Consistent with the supply-side issues, the FCC estimated that high-speed subscribers were present in 97% of the most densely populated zip codes by the end of 2000, whereas they were present in only 45% in the zip codes with the lowest population density (NTIA 2004).

Prices for broadband were ostensibly higher than twenty-dollar per month norm for dial-up, so users faced a price/quality trade-off. Different preferences over that trade-off shaped the margin between adopter and non-adopter. For example, if the user were already paying twenty dollars a month for ISP service plus an additional charge for a second line, moving to broadband at forty dollars a month while retiring the second line would not seem like a large trade-off in price. [76] Indeed, because so much demand moved from dial-up to broadband, official U.S. price indices did not show any appreciable decline or rise in the price of monthly contracts for Internet access during this time-period.[77] While this shift in demand hurt pricing at dial-up firms, it supported prices at broadband firms.

The availability of broadband motivated some new Internet use at households, but not much among the heretofore non-adopters. Hence, broadband demand largely cannibalized existing dial-up demand, resulting in one-quarter of U.S. households using broadband in 2003. Access revenues for dial-up were just over 10.5 billion, while cable modem and DSL were over 12.9 billions dollars.[78]

Overall, broadband diffused within the context of reduced demand uncertainty, a factor that made it different from the diffusion of dial-up access. There were still many questions about the details of these business operations, such as its cost and pricing, but there was a consensus about the broad direction of change.

2003b – Wireless Access in the United States

The value of upgrading to wireless data services was anticipated by nearly every market vendor, user, and policymaker, but the form of its delivery was undetermined. As with dial-up, the American experience differed from the patterns that emerged in other countries, which also suggests that innovation in Internet access markets still could lead to unexpected outcomes. The United States saw three major modes of wireless access.

The first was a significant and large group of users who retrofitted a connection to their laptop computer, which was labeled *Wi-Fi.* Wi-Fi required a hot-spot in a public space or a special server at home or business. A hot-spot in a public space could either be free, supported by the café or restaurant trying to support its local user base or attract a new one, or be subscription-based, with users signing contracts. The latter was common at Starbucks, for example, which subcontracted with T-mobile to provide the service throughout its cafés. The specific details behind the growth of Wi-Fi had a "bottom-up" quality reminiscent of the first wave of enthusiasm for the Internet. It also lacked regulatory guidance (except for restrictions on unlicensed spectrum, which the FCC guided). Both perceptions appealed to technically sophisticated users, who experimented with Wi-Fi.

The development of Wi-Fi occurred as follows: Wi-Fi involved a technical standard from the IEEE subcommittee for Committee 802. Committee 802 was well known among computing and electronics engineers because it had helped diffuse the Ethernet standard that Bob Metcalfe designed decades earlier. Subcommittee 802.11 concerned itself with wireless traffic for LANs using Ethernet protocol. In 1999, it published Standard 802.11b, which altered some features of an earlier attempt at a standard for local Ethernet protocol (increasing the speed, among other things). Because many vendors had experimented with earlier variations of this standard, the publication of 802.11b generated a vendor response from those who were already making equipment.

Committee 802.11 did not initially intend to design a wireless standard for generating Internet access in coffee shops or other public spaces such as libraries. The designers focused on traditional big users (e.g., FedEx, UPS [United Parcel Service], Wal-Mart, Sears, and Boeing) who would find uses for short-range Ethernet. In this sense, their original charter was quite narrow. The publication spurred more commercial experiments.

Around the same time, pioneers of the standard—including 3Com, Aironet (now a division of Cisco), Harris Semiconductor (now Intersil), Lucent (now Agere), Nokia, and Symbol Technologies—formed the Wireless Ethernet Compatibility Alliance (WECA). As a marketing ploy for the mass market, WECA branded the new technology Wi-Fi. Related to these goals, the group also performed testing, certified interoperability of products, and promoted the technology. In 2003, in recognition of its marketing success, WECA renamed itself the Wi-Fi Alliance.

In the midst of 2003, Intel announced a large program to install wireless capability in its notebooks, branding it *Centrino*. This action was regarded as an unusual strategic move by many

Wi-Fi participants because embedding a Wi-Fi connection in all notebooks did not involve redesigning the microprocessor, which Intel made. It involved redesigning the motherboard, eliminating the need for an external card. Intel made prototypes of these motherboards and branded them. It hoped that its endorsement would increase demand for wireless capabilities within notebooks. Non-trivially, it also anticipated that the branding would help sell notebooks using Intel chips and designs, much as the "Intel Inside" campaign had.

Intel ran into several snafus at first, such as insufficient parts for the preferred design and a trademark dispute over the use of the butterfly, its preferred symbol for the program. Also, and significantly, motherboard suppliers, card makers, and OEMs (original equipment manufacturers) did not like Intel's action, as it removed some of their discretion over the design of notebooks. Yet, by embedding the standards in its products, Intel made Wi-Fi, or rather Centrino, easy to use, which proved popular with many users. Only Dell was able to put up any substantial resistance, insisting on selling its own branded Wi-Fi products right next to Intel's, thereby supporting some of the card makers.

Despite Dell's resistance, the cooperation from antenna makers and (importantly) users helped Intel reach its goals. Centrino became widely diffused. Intel's management viewed this outcome as such a success that it invested in further related activities, such as upgrades (to 802.11n) and a whole new wireless standard (to 802.16, a.k.a. Wi-Max).

The second significant set of wireless users were Blackberry enthusiasts, who numbered several million. Research in Motion (RIM) sold these and had explored these applications for many years. The Blackberry was a small, light-weight device designed solely to send and receive e-mail text messages, using digital cellular infrastructure to carry the signal. Research in Motion focused on corporate e-mail users, to whom it sold a software process that easily and securely forwarded business e-mail. Blackberry was thought to have over two-thirds of the market for mobile e-mail use. No other firm's implementation was as popular, either from Microsoft or a partner, or from Palm or a partner.

The third and least popular mode for wireless data services in the United States was a form of text-messaging using cellular handsets. Most of these used second-generation GSM (global system for mobile communication) designs, imitating practices in other developed countries where these designs were much more widespread. Despite their limited availability by 2003, those applications had not captured popular imagination in the United States. The alternatives were more functional and less expensive.

Vendor and user perceptions in the wireless area were in flux at this time because no sensible observer would have forecast that this situation would persist. The cellular carriers and their equipment providers were open about their ambitions to develop applications. There were well-known plans to upgrade Wi-Fi. Nor was Microsoft shy about its ambitions to foster alternatives on hand-held devices using Windows CE, nor was Palm about its desire to add wireless capabilities to its popular organizers. More experimentation with hardware form factors and software applications was anticipated. No observer could reliably forecast which of these would most appeal to users and generate the most revenue or profit.

2003c – From new Adoption to Capital Deepening with Business Users

Stocks of information technology capital grew at a 20% annual growth rate from the end of 1995 to the end of 2000.[79] By 2000, computer hardware and software stocks had reached $622.2 billion.[80] The majority of this investment was affiliated with enabling business applications. In 2000, total business investment in IT goods and services was almost triple the level for personal consumption of similar goods.[81] The level and growth of investment dropped off considerably after 2000, flattening in 2001, 2002, and 2003.

There seemed to be several reasons for the flattening of investment in IT technology. To begin, there was a saturation of certain types of Internet adoption. In some businesses, the Internet had been adopted across all facets of economic activity, while in others adoption was not widespread. What explains this variance? There were many purposes for the Internet in business.[82] The simple first purpose, *participation*, relates to activities such as e-mail and Web browsing. This represents minimal use of the Internet for basic communications. By 2003, most businesses had made the investments necessary to participate. Indeed, adoption of the Internet for purposes of participation was near saturation in most industries as early as 2000.

A second purpose, *enhancement*, relates to investment in frontier Internet technologies linked to computing facilities. These latter applications are often known as e-commerce, and involve complementary changes to internal business computing processes. Hence, most of the investment by 2003 was affiliated with refining the more complex applications (i.e., enhancement), and those business segments were more specific rather than widespread. Heavy Internet technology users tended to come from the historically heavy IT users, such as banking and finance, utilities, electronic equipment, insurance, motor vehicles, petroleum refining,

petroleum pipeline transport, printing and publishing, pulp and paper, railroads, steel, telephone communications, and tires.

Why did this pattern between participation and enhancement investment emerge? First, the applications with the most demand were e-mail and browsing. Investments that went beyond that were complex and costly, but potentially valuable to some firms. Specifically, those that had invested in advanced IT in the past had the staff, equipment, and need to invest in complex applications.

Second, most firms are incremental in their approach to complex investment in IT—compromising the benefits of frontier technology and the costs of keeping an existing process, they pick and choose among those new possibilities that make the most sense for their business. Hence, few industries with little experience in advanced IT suddenly chose to become a heavy investor when the Internet commercialized.

Third, investment in innovative IT is directed toward automating functional activity or business processes within an organization, such as accounts receivable, inventory replenishment or point-of-sale tracking.[83] Such processes only change slowly, if at all. Even if firms wanted to invest, it was difficult to do so without affecting current operations.

Finally, in addition to the types of investment available, the dot-com bust affected the Internet access market, as a large secondary market for used equipment from recently bankrupt dot-com and CLECs depressed prices for new equipment. Firms with major businesses in selling equipment into Internet access markets suffered from the drop in sales in 2003.These demand conditions affected every leading equipment firm, such as Cisco, Lucent, Nortel, JD Uniphase, Corning, and many others. In addition, a large number of start-up firms with projects developing frontier products found themselves without any potential buyer and without a realistic possibility for an IPO. Many of the venture capital funds for these communications equipment firms had not reached a profitable state by 2003.

Enterprise computing stood at a cross roads, and therefore so stood a large segment of the Internet access market. By 2003, many business operations were increasingly dependent on the reliable operation of the Internet. That heightened questions about the ability of the Internet to support secure transactions, withstand terrorist attach to infrastructure, or survive malicious virus attacks to the operating software. It also heightened questions about scaling the Internet to many devices. For example, IPv6 allowed for a large expansion in the number of Internet addresses, alleviating a potential problem that most technical insiders forecast. Though defined in 1994 by

the IETF, the slow diffusion of IPv6 did not inspire confidence about the ability of the Internet to scale in the next decade when it involved so the uncoordinated actions of so many firms.

In 2003 a number of potential future high-value applications were being discussed, but none had yet diffused widely. Voice-over IP and applications of the wireless Internet were among the most popular among futurists. Most examples of high-impact applications were still confined to frontier users in business and homes, except for a few mobile applications. That was no more than a small percentage of total Internet usage.

2003d –Market Leadership

It is inherit in exploratory activity that vendors have discretion to take risks, assemble information, and generate assessments about future prospects. It is inefficient for stockholders, regulators, or auditors to question every aspect of a firm's decisions at every moment in time. Yet, publicly traded companies, and even most privately held ones, do not retain such discretion indefinitely. Periodically managers' decisions will be reviewed by someone, such as a corporate board, an internal or external audit team, skeptical stockholders, or financial reporters from newspapers.

Such reviews at a number of key firms in the Internet access business generated a number of scandals. These scandals raised questions about the long-run economic viability of the U.S. Internet networks, and these questions led observers to wonder in retrospect whether some Internet infrastructure investment had been excessive.

From 2000 to 2002, Internet investment took a downturn. When quite a few of the CLEC firms did not realize their commercial promises, losing significant financial value in a short period, their losses became known as the Telecom Meltdown. Financial support for dot-coms declined in the spring of 2000 and was popularly labeled "the dot-com bubble burst." Then the September 11 terrorist attack in 2001 shook business confidence in long-term investments. This low continued as the WorldCom financial scandal became publicized in the spring of 2002.

Many observers believed the United States had extraordinarily high levels of "dark fiber," that is, capacity for carrying data that went unused (or "unlit"). Qwest, Level3, Sprint, Global-Crossing, MCI-WorldCom, Genuity (formerly the backbone for GTE), Williams, PSINet, AT&T, and others, came under this suspicion because all of them invested heavily in redundant transmission capacity during the boom. In addition, technical advances in multiplexing allowed owners of fiber to use existing capacity more efficiently, increasing the efficiencies from (or

reducing the costs of) using existing conduit by order of magnitudes. By 2003 industry insiders forecast that there would not be sufficient growth in demand to use up the capacity in existing national fiber for anytime into the indefinite future. As expected in a market with overcapacity, plenty of evidence suggested that buyers of large amounts of bandwidth experienced drops in prices for carrying data over long distances from one major city to another.[84]

Financial scandal also hit the Internet carrier business. A division of WorldCom, UUNET was the largest backbone data carrier in the United States. Although UUNET did not have any accounting problems, accounting scandals at its corporate parent led to the bankruptcy of WorldCom. PSINet and Global Crossing also overextended themselves and had to declare bankruptcy. Genuity did the same to facilitate merging with Level3. And Qwest and AT&T overextended themselves financially and went through dramatic management changes and restructuring. So too did AOL after a merger with Time/Warner.

The crisis in the financial conditions of many leading firms did not generate a coordinated response from agencies in charge of communications policy, such as the FCC. Following long-standing norms, regulators would not act unless U.S. communications were interrupted by bankruptcy and restructuring. Thus, improving the financial solvency of companies was left to the discretion of managers, their corporate boards, and debt holders.

An objective observer in 2003 would have found it difficult to have full confidence in the leaders of the Internet access industry from a similar list made a half decade earlier. The market leaders from five years ago had all made errors of strategy or accounting. America On-Line, WorldCom, AT&T, Enron, Qwest, Global Crossing, Genuity, PSINet, and MCI had all lost their status as trustworthy leading firms in many aspects of their businesses. Many had lost their identities altogether as distinct firms, while others tried to hire managers to work through the crisis and help the organizations emerge anew with sound operations in the remaining businesses. To be sure, despite financial crises, the largest of them, AT&T, Qwest, and WorldCom, all continued to offer services and none of them suddenly lost many customers for their data services.

Only a few of the entrants of the prior decade could claim a leadership position, such as Earthlink/Mindspring, Juno/Netzero, or Level 3. Other firms, such as IBM, Accenture, Microsoft, Intel, or Cisco, that spoke with authority about the Internet access market, were involved in the broad Internet infrastructure business in many respects, not just Internet access as a the only market service.

A new set of market leaders also emerged from among the firms that had had more conservative behavior—especially broadband carriers. Cable companies, due to their investments, established the largest market share—such as Comcast, which had bought the cable plant for home provision from AT&T. The three gigantic and financially sound local telephone firms (e.g., Verizon, SBC, and Bell South) had the next largest market share. These firms were increasingly providing the wire-line broadband access to homes across the country. Mergers of local telephone companies further resulted in a consolidation of managerial decision making over the assets affiliated with deploying DSL in the United States, as well as partially over the major backbones.

To the enthusiasts who helped initiate and catalyze the growth of the Internet these outcomes in 2003 seemed like a cruel cosmic joke. The scandals, strategic missteps, and mergers helped bring about a decline in once–high-flying entrepreneurial firms, which naturally led to a decline in the founding of new firms after 2000. With aid of regulatory rulings favoring incumbents who owned facilities, a set of firms that were among the least entrepreneurial at the outset of the new technology market in 1993 began to acquire a position of commercial leadership in 2003. These firms also stood for centralized management of technological opportunities, the cultural antithesis of what the more rebellious parts of the Internet community supported.

These firms took a different view, arguing that their prudence allowed them to capitalize on the business excesses of others. In addition, they pointed to their distinct assets and competitive advantages, arguing that the new technological opportunities favored their organizations' comparative advantages under almost any regulatory setting.

By the end of 2003 a new debate began about whether any regulatory intervention was needed to curb the actions of the largest data carriers. Given the label "net neutrality" by its proponents, it proposed curbs on retail and whole discriminatory practices by broadband carriers. That is, it proposed bans on blocking access to content and some forms of tiered pricing for different services. At the end of 2003 this debate was far from resolved.

2003e – Merger and Regulatory Policy

Legal challenges to the 1996 Act continued well into 2003, altering all the important rules for interconnection and access—what could be unbundled, prices for renting unbundled elements, and, eventually, the definitions for the boundary between an information service and a telecommunications service. In general, seven years of rule changes did not give participants a

clear prediction about the market conditions that governed their investments. Even seven years after the passage of the 1996 Act, one key provision after another received a new interpretation or implementation, either due to changing court rulings or regulatory interpretations from new FCC commissioners. Prior investments either became more or less valuable. All firms learned their lessons quickly: The value of exploratory investments depended critically on decision making in Washington D.C. and the rulings at the courts hearing one lawsuit or another.

For example, the FCC gradually reduced the ease with which competitors could make use of the unbundled elements of incumbent networks. Mandated by court rulings, in 2002 the FCC began to adopt a set of rules designed to discourage others from using new investments in broadband, thus encouraging local telephone companies to invest in broadband. By 2005, ILECs were not obligated to make most DSL service available on a wholesale basis to resellers.

Interpreting and implementing this area of regulation became one of the most contentious chapters in U.S. telecommunications policy. The policy debates did not take place in the face of calm deliberations of historical facts, but became opportunities for strident expressions of belief and viewpoints, further amplified by lobbyists and the concerns of key politicians. Needless to say, the role of concentrated provision in fostering exploration was not the most salient factor in either side's public stance. More to the point, the summary below is but a brief oversimplification of a complex and extensive set of arguments.[85]

To some, the FCC's decisions to favor "facilities based competition" were seen as aiding U.S. competitiveness and productivity. For example, the FCC made it easier for telephone firms and cable firms to deny access to any third-party ISP or CLEC that had taken advantage of "regulatory expropriation" rather than invest in its own physical facilities. In addition, telephone company executives and shareholders had long considered themselves as unfairly disadvantaged by the unbundling requirements in the 1996 Telecommunications Act, as well as by the asymmetries in the applications of enhanced service rules. Hence, these rule changes also were interpreted as righting a prior wrong.

Views of the opposing camp were as equally strident. The rule changes were considered as an outrageous attempt to prevent CLECs from competing and as a means to close channels to firms other than owners of bottleneck assets in the national communication infrastructure. Many of the bankruptcies of CLECs in the last few years were portrayed as the result of anti-competitive actions by cable and telephone companies. In this light, the changes were viewed as a capitulation to political and regulatory lobbying by phone and cable companies, not fixing the

correct problem, nor using any measured consideration of policy. Cynics pointed to the explicit political pressure coming from House of Representatives, which passed the Tauzin-Dingle Bill in February 2002. Though the bill did not pass the Senate that year, it called for some of the same features the FCC adopted in 2003. Cynics argued that policy seemed to help well-connected telephone and cable companies at the expense of the less-experienced firms. To the Internet enthusiasts, who viewed the growth of the Internet as a rebellion of outsiders, these rule changes also were viewed as Goliath's conspiracy to support the old establishment – i.e., cable firms and telephone firms – in the face of a technical entrant – i.e., CLECs, ISPs and many related infrastructure firms.

Merger policy also took on increased importance. The Bush administration continued with earlier trends of allowing mergers among local telephone firms. Eventually Verizon combined assets from what used to be Bell Atlantic, Nynex, GTE and, in 2005, the financially weakened MCI/WorldCom. Eventually, SBC combined assets of Southwest Bell Corporation, Southern New England Telecommunication, Ameritech, the Pacific Bell Company, and, in 2005, what was left of AT&T's long-distance and local service, including its Internet business. Also, SBC took AT&T as the corporate name thereafter. [86]

Concerns about ownership of bottleneck facilities played little role in these mergers. No divestitures were required as a condition for the 2005 mergers, a striking feature since the market coverage of the firms did geographically overlap and the acquiring firms in this case, local telephone firms, managed many points of access to telephone switches. One condition did emerge from negotiations. The telephone companies were required to sell "naked DSL" services, i.e., purchase of DSL service without a dial-tone. In plain language, a customer did not have to purchase of voice service to get DSL services. This was not an onerous requirement for telephone companies in comparison to the many things that could have been imposed.

Overall, the most notable policy decisions in 2003 facilitated a shift in policy favoring the consolidation of ownership of assets in the operation of telephone networks. This came from two fronts, the change in rules for the resale of unbundled elements and from merger policy. More consolidation from merger would come within the next few years. This consolidation opened questions about whether the public policy directive to achieve financial solvency in access markets and upstream backbone markets led to too much reduction in redundant investment. Had the US retained sufficient redundancy for firms to competitively discipline one another for unwarranted price increases or undesirable non-price vendor behavior? This reduction also raised

questions about whether owners of bottleneck facilities could expropriate returns from innovation conducted by firms offering complimentary services. Only events in the next decade could answer such questions.

2003 – Overview

The Internet of 2003 would shock a market participant from a decade earlier. The novel had become routine. Access markets became a reliable functioning part of the Internet, invisible to most users, yet still changing in reaction to new opportunities and new regulatory rulings.

By 2003, the set of identities of the market leaders expanded dramatically. Financial scandals, and events known popularly as the Telecom Meltdown and the dot-com bubble burst, reduced the flow of financial resources to this sector. This and the absence of growth in demand led to financial hardship. In addition, financial and accounting scandals came to light, involving some of the industry's highest profile participants.

Summary of the First Decade

There is a cliché from canonical narratives of technical new industries: In a setting where cautious or unaware market leaders have no reason to alter their business, the intrepid entrepreneurial firms may be the first to take risks and seek customers. The absence of concentration enables those so-called contrarians to reach the marketplace sooner and initiate innovative responses from incumbents. The incumbent response then determines whether the commercial efforts of the entrants lead to changes in market leadership or not.

The Internet access experience does reflect this cliché in some respects. In 1993, few observers recognized that the setting would change so dramatically. A variety of firms saw a market opportunity and developed their commercial services before incumbent firms, ultimately demonstrating the viability of commercial Internet access service. After that, competitive pressures accelerated the adoption of innovative practices by a variety of providers. Their actions collectively initiated a commercial revolution. Any reasonable reading of this history has to conclude that this revolution would have been delayed had the entrepreneurial firms not acted.

Yet, the cliché' also simplifies the role for variety. The commercial Internet access market did not involve just only one key difference between the views of entrants and incumbents. Rather, an ensemble of firms approached the new opportunity in 1993. At first a few firms invested, while most did not. They did not speak with one voice, or, for that matter, necessarily share the same vision about the source of commercial value. By 1998, all participants could reliably forecast growth in demand. In that setting a variety of approaches flourished. Yet, experts still disagreed about the most valuable form of service and business operations, and, for that matter, the likely identities of future commercial leaders. Even by 2003, after a number of routines emerged for commercial behavior and consolidation reduced the range of differences between some leading firms, firms were developing new access modes in broadband and wireless markets. Innovation was creating new value yet again.

The canonical cliché' also overlooks the nurturing institutional setting in which the commercial Internet diffused. The commercial dial-up access market was the unanticipated result of the partnership between telephone companies and ISPs. At the outset, this relationship was mutually beneficial but fragile. Legal precedent held it together at first. The unexpected and massive commercial opportunity turned it into a key component of almost every firm's activity.

As the first decade of the commercial Internet came to a close, this relationship had come under severe strain, affected by two powerful and distinct roles for regulation in spurring innovation. On the one hand, entrepreneurial firms were unlikely to undertake risky innovative activity if they experienced changes in regulatory and legal environment that protected them. On the other hand, publicly traded firms, such as a telephone company or cable firm, were unlikely to undertake large scale multimillion dollar investment in the face of regulatory and legal uncertainty about the financial returns on their investments. At the outset policy inherited rules that emphasized the former principle, nurturing innovative activity out of ISPs. At the end of the decade policy tried to improve incentives for large telephone companies, and only later events would tell whether this came at the expense of the first principle.

The entire decade is also astonishing for the number of unplanned but ultimately complementary accidents that transformed the Internet from a communications tool for researchers into a strategic investment priority for every firm in commercial computing and communications. NSF's managers gave the Internet access market a nurturing beginning, but that did not determine the outcome, nor could it. NSF had the good fortune to inherit competitive norms from computing and regulatory rules from communications that nurtured commercial

experiments from a variety of firms. Other on-going regulatory decisions could have done a great deal of harm, by discouraging development of new operational practices and the discovery of the sources of value in nascent demand. Yet, a fair reading has to conclude that such massively poor judgment did not occur. Though not all regulatory actions in the first decade were nurturing to innovation, a fair characterization of the first decade can acknowledge both the challenges faced by, and the impressive achievements of, the participants in the young Internet.

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Endnotes

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[2] To be sure, this is a statement about the size of activity, not the private or social rate of return on investment. In the 2004 Service Annual Survey (released by the U.S. Census Bureau on December 29, 2005) NAICS 514191, Internet Service Providers had $10.5 billion in access fees in 2004; NAICS 5132, Cable Network and Program Distribution, had $8.6 billion in Internet access service; and NAICS 5133, Telecommunications Carriers, had $4.3 billion in Internet access services. This does not count the revenue for other on-line services.

[3] See Owen (2002).

[4] For example, see the series of studies on use by the National Telecommunications Information Administration (NTIA) (1995, 1997, 1998, 2002, 2004), or the surveys of use done by the Pew Internet and American Life Project at www.pewinternet.org. For a summary of the writing on the geography of the digital divide, see Greenstein and Prince (2006).

[5] There is considerable writing in each of these veins. See e.g., Lessig (1999), Sidak (2003), Crandall (2005), Neuchterlein and Weiser (2005), and Blumenthal and Clark (2001) among many. This list is hardly exhaustive.

[6] See e.g., OECD, 2000, *Local Access Pricing and E-Commerce.*, July. Other practices also have received attention. For example, the U.S. market attracted more than half a dozen backbone providers, while most countries had one or only a few (Economides, 2005, Hogendorn 2003). In addition, for many years U.S. access firms sold portfolios of new services, taking organizational forms that no other country's firms had (Greenstein 2001). The causes behind the dot-com boom and bust have also attracted attention (e.g., Kenney, 2003, Zook, 2005, Goldfarb, Kirsch, and Miller 2006), and this essay will address overlapping determinants in access markets.

[7] This is a simplification of a complex history. See e.g., Kahin (1992), Frazer (1995), Abbate (1999), Mowery and Simcoe (2002), Ceruzzi (2006) and Haigh (2006).

[8] In an intriguing footnote, Abbate (1999, p. 239), states that this structure was probably inspired by the structure of the telephone industry at the time, with a mix of regional networks and national interconnection. It in unclear how much of this inspiration was "conceptual" and how much was simply

"following path of least resistance" because the national telephone carriers, Sprint, MCI, and AT&T, could use their existing assets to provide backbone services.

[9] This statement necessarily oversimplifies a long institutional history. There were many earlier attempts to establish internal pricing within universities for incremental use of computing services. Most of these had died out many years earlier, instead replaced by indirect funding mechanisms supporting IS department budgets that provided services for students and faculty without usage charges. This principle extended to use of modem banks. For the early history of this practice, see Aspray and Williams, 1994.

[10] Once again, this is a simplification. See Kahin (1992), Frazer (1995), Mowery and Simcoe (2002), Abbate (1999), Ceruzzi (2006) and Haigh (2006).

[11] Note that the date for the existence of the first commercial ISPs is 1991-1992, *prior* to when the NSF began to lift the acceptable use policy for commercial activity over the Internet. These firms were already anticipating operating a private network that would bypass the public funded Internet backbone. For example, three of these networks, PSINet, CERFNet, and Alternet, formed the Commercial Internet Exchanges in July 1991 for the purpose of exchange traffic outside the publicly funded data-exchange points.

[12] Other sources show a similar trend. In one of the earliest Internet "handbooks," Krol (1992) lists 45 North American providers (8 have multi-city national presence). In the second edition of the same book, Krol (1994) lists 86 North American providers (10 have national presence). Marine and colleagues (1993) list 28 North American ISPs and 6 foreign ISPs. Schneider (1996) lists 882 ISPs in the United States and 149 foreign ones.

[13] See e.g., Swisher, 1998, for an accessible comparison of the AOL/MSN differences and similarities – especially their market positions and strategic approaches – during the mid 1990s.

[14] Krol (1994) gives a good sense of movement prior to 1995. For a description of the type of resistance encountered by foresighted entrepreneurs during this time, see e.g., Ferguson 1999.

[15] See, e.g., Meeker and Dupuy (1996). This team of analysts was not the first one to organize a systematic analysis of the vendors in the market. The first stage venture capital firms certainly were earlier. To my knowledge, however, it is among the earliest publications for general investors from an established Wall Street organization.

[16] Note, however, that a full comparison of the regulatory/industry relationship in other countries will be left for future work; this essay concentrates on only the U.S. experience.

[17] There is a very long history behind these events and this essay reviews only a part. See e.g., Noll and Owen (1989), Werbach (1997), Oxman (1999), Cannon (2001), Owen (2002), and Hogendorn (2005).

[18] In addition, in Judge Green's administration of the modified final judgment of the divestiture of AT&T there were bright lines regulating local telephone firm involvement in enhanced service markets. See Noll and Owen (1989) or Nuechterlein and Weiser (2005).

[19] This is a simplification for the sake of brevity. Vendors did learn what was possible, but the engineering challenges turned out to be manageable. See Werbach (1997) or Oxman (1999).

[20] This transition is very apparent by the 1997 and 1998 editions of Boardwatch Magazine's directory of bulletin board operators and ISPs.

[21] See the discussions in Aspray (2004) chapter 2, and Cronin (2006). As further evidence, the 1996 edition of Boardwatch Magazine's directory makes it apparent that these firms were geographic dispersed across the country.

[22] See, e.g., Friedan (2002).

[23] See, e.g., Gerstner's account of the resistance he met trying to move the firm to support technologies, such as Unix and Microsoft-client software, from outside those found in mainframes. He argued that, in retrospect, these changes were among those that were most beneficial for the long term health of the firm.

[24] Ferguson, 1999, contains a detailed account of the founding of Vermeer in 1994, a company that aimed to provide software for Internet applications and servers. It provides a variety or reasons why so few new firms were founded this early.

[25] Under the original design plans for Windows, there were two target markets, one aimed at PC clients and one at servers. TCP/IP compatibility had value for server software as a direct competitor to Unix systems. It also had value because it eased data exchange between server and client.

[26] Design decisions for the OS were receiving attention from the highest level of the company, including Bill Gates, Steve Balmer, Nathan Myrvold, and all the other corporate officers who made up the "brain trust" for the firm. The acknowledgement of the error and change in strategy came in April-May of 1995, after a publication of an Internal memo titled "The Internet Tidal Wave." See Gates(1995).

[27] This is a necessary summary of a long set of complex events. See e.g., Haigh (2006), Bresnahan and Yin (2006), and Bresnahan, Greenstein and Henderson (2006).

[28] To my knowledge no research has traced fully the "pork barrel" in the NSFNet, which favored IBM, MCI, BBN (Bolt Beranek and Newman), the local economies built around super computer centers who NSF subsidized, and, arguably, some of the young entrepreneurial firms who descended from the NSFNet. It also favored the many universities that received subsidies to establish Internet connections, as well as the computer science departments whose faculty and students worked in supercomputer centers and in broader computing centers that provided Internet access. The contemporary public justification for these

subsidies emphasizes the traditional justification, i.e., the technical goals or research accomplishments of the projects and other publicly spirited goals affiliated with subsidizing R&D (e.g., see the discussion in Frazer, 1995, or Abbate, 1999).

[29] This is a longer story. See the accounts in Ceruzzi (2006), Aspray (2004) Chapter 3, and Mueller (2004).

[30] See, e.g., Berners-Lee and Fischetti (1999).

[31] Once again, this simplifies a complex story. See e.g., Abbate (1999) or Simcoe (2006).

[32] See Ceruzzi (2006) for more about these events.

[33] Approximately 26% of U.S. households had Internet access in 1998, up from 18.6% the year before. Cable companies accounted for only 2% of subscriptions. Local telephone companies accounted for only 10%, so the number of broadband connections was relatively small to homes.

[34] NTIA (1998) shows that National service providers, telephone companies, and cable companies accounted for just under 90% of household subscriptions. The NTIA surveys do not begin to track broadband users until August, 2000, when the survey finds that 4.4% of U.S. households are broadband users (with 41.5% of households being Internet users).

[35] See, e.g., Downes and Greenstein (2002, 2006). Also see Stranger and Greenstein (2006).

[36] See Downes and Greenstein (1998).

[37] See e.g., Friedan (2002), or Kahin (1997).

[38] Among those sometimes counted as tier-1 providers are Genuity, Qwest, IXC, Williams, and Level3. See Kende (2000), Hogendorn (2003), or Economides (2005) for different discussions.

[39] See, e.g., Besen et al (2001) or Besen et al (2002).

[40] See Hogendorn (2003) for a description of this institution.

[41] See contemporary summaries of these debates in Oxman (1999) and Kende (2000).

[42] Technical practices improved. In 1993, the connections offered were tended to be UUCP (unix-to-unix copy) connections that were capable of exchanging files, newsgroups and e-mail, but they had no interactive features. By 1998 (and probably as early as 1995), all of the ISPs supported SLIP (serial line internet protocol) access, a more highly interactive connection that has all the capabilities of UUCP plus additional features (including multimedia capabilities). This became obsolete comparatively soon, as most ISPs began to use PPP (point-to-point protocol). For a broader discussion of these and other technical issues, see Haigh (2006).

[43] See, e.g., Greenstein, 2000, O' Donnell, 2001

[44] Many observers remarked about the wide variety of content in this time. For a statistical sample of use, see, e.g., Clemente (1998).

[45] AOL had a sizable market share in 1994-95, but not this large. This dominating share emerged in 1996-97 and especially after the CompuServe acquisition. For a recounting of the philosophical and marketing strategies that led to this outcome, see e.g., Swisher (1998).

[46] Most services offer a feature known as *presence,* indicating whether people on one's list of contacts are currently available to chat. This may be called a *buddy list*. In some Instant Messaging programs, each letter appears as it was typed or deleted. In others, the other party views each line of text after another is started.

[47] Microsoft was willing to pay cash, but AOL drove a hard bargain, perceiving that Microsoft's program of compelling promotion of Internet Explorer 3.0 among all ISPs and OEMs could not succeed without signing a large vendor such as AOL. After considerable negotiation back and forth, AOL signed Netscape up as a browser but did not the exclusive default browser. Under the pressure that this contract would go unanswered, Microsoft relented to AOL's terms for making Internet Explorer the default browser. Once Microsoft's manager capitulated to AOL's terms, many MSN employees left. Altogether, the deal helped Microsoft's browser business, but set back MSN's ambitions—MSN had been one of AOL's biggest competitors until that point. AOL lost the network of firms supported by Netscape, but gained dominance in the US Internet access business. Microsoft did many other things to support Internet explorer. See e.g., Cusumano and Yoffie (1998) or Bresnahan (2003) or the discussion in Swisher (1998).

[48] In 1999, AOL bought Netscape—particularly its portal, well after the browser wars ended. The merger with Time Warner was proposed in January 2000.

[49] See e.g., Eisner and Waldon (2001), or the discussion in Rosston (2006).

[50] The section provides a summary of Greenstein (2005). Also see Gorman and Malecki (2000).

[51] This is a simplification of a wide variety of circumstances. See, e.g., Forman (2002).

[52] See Downes and Greenstein (2002).

[53] In a study of the Appalachians and some areas with histories of poor communications service, Strover, Oden and Inagaki (2002) examine ISP presence in the states of Iowa, Texas, Louisiana, and West Virginia and determine the availability and nature of Internet services from ISPs for each county. See also, Strover, Sharon (2001).

[54] For example, see Nicholas's (2000) study of the multiple attempts to provide access to rural Texas communities. He shows how the construction of calling-area geographic boundaries shapes the entry patterns of ISPs. His study shows both the strengths and pitfalls of this policy approach.

[55] See Downes and Greenstein (2002).

[56] For a sense of these plans, see Boardwatch directories, various years.

[57] For more on this, see Odlyzko (2001), or Coffman and Odlyzko (2002).

[58] Stranger and Greenstein (2006).

[59] This summarized an extended crisis at the company. See the full chronicle in Swisher (1998).

[60] Some ISPs also instituted automatic session termination when an online user remained inactive, eliminating problems arising from users who forgot to log off. Customers, however, perceived this as poor service; consequently, many small ISPs hesitated to employ it.

[61] Stranger and Greenstein (2006).

[62] See the estimates in Stranger and Greenstein (2006).

[63] For a history of standards in the Internet, see Simcoe (2006).

[64] For a discussion of the factors shaping this outcome, see Greenstein and Rysman, 2006.

[65] There is a long history of regulating interconnection to the telephone network. For a discussion of many of the antecedents to, and rationales for, the approach taking in the Telecommunications of 1996, see Noam, Eli. 2001, or Nuechterlein and Weiser (2005). For a discussion of CLECs, see, e.g., Woroch (2001), Greenstein and Mazzeo (2006), or NPRG (2000).

[66] Even though the behavior was legal from a literal perspective, it was ***not*** the behavior Congress had intended to induce. FCC docket No. 99-38, Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, Inter-Carrier Compensation for ISP-Bound Traffic, released February, 26, 1999.

[67] The Act also barred multiple and discriminatory laws on e-commerce It contained sunset provisions, but was renewed several times subsequent to initial passage. It did sunset briefly in 2003, only to become renewed in early 2004.

[68] Shiman and Rosenworcel (2002).

[69] See e.g., Woroch (2001).

[70] NTIA (2004) shows a survey of households in October 2003, in which 20.6% had cable modem access, while 15.2% had DSL access, and 62.8% had dial-up access.

[71] For a complete history, see Rosston (2006).

[72] For some statistics on this, see Bauer (2006).

[73] This is a long and complex story. For different views, see e.g., Crandall (2005), Bauer (2006), Rosston (2006),

[74] This is the nonamplified radius; the signal could reach further with amplifiers. The 18,000 feet only applies to service of up to 1.5 Mbps; for higher speeds, the radius is more limited. For example, for speeds of 8 Mbps, the limit is 9,000 feet and for VDSL (very high bit-rate DSL), which could supply up to 55 Mbps, the limit is 1,000 feet.

[75] See Grubesic and Murray (2002), Gabel and Kwan (2001).

[76] The cost of a second line varied, depending on the state. See Eisner and Waldon (2001).

[77] See Bureau of Labor Statistics price series for Internet Services and Electronic Information Providers. This price series begins in December 1997 at 100. By December 2003, it had reached 97.6 – in other words, measured transaction prices for Internet service declined by 2.4% in six years.

[78] According to the 2004 Service Annual Survey, released by the U.S. Census Bureau on December 29, 2005, NAICS 514191, Internet Service Providers, had $10.5 billion in access fees in 2004; NAICS 5133, Telecommunications Carriers, had $4.3 billion in Internet access services; and NAICS 5132, Cable Network and Program Distribution, had $8.6 billion in Internet access service.

[79] This includes computer hardware, computer software, and communications hardware and instruments. See Price and McKittrick (2002) or Henry and Dalton (2002). The growth rates are even higher if communications hardware and instruments are excluded.

[80] These are constant (1996) dollars. See Henry and Dalton (2002).

[81] For 2000, estimated personal consumption of IT goods and services was $165 billion. For business it was $466 billion. See Henry and Dalton (2002).

[82] This discussion is based on Forman, Goldfarb and Greenstein (2003a, 2003b, 2005).

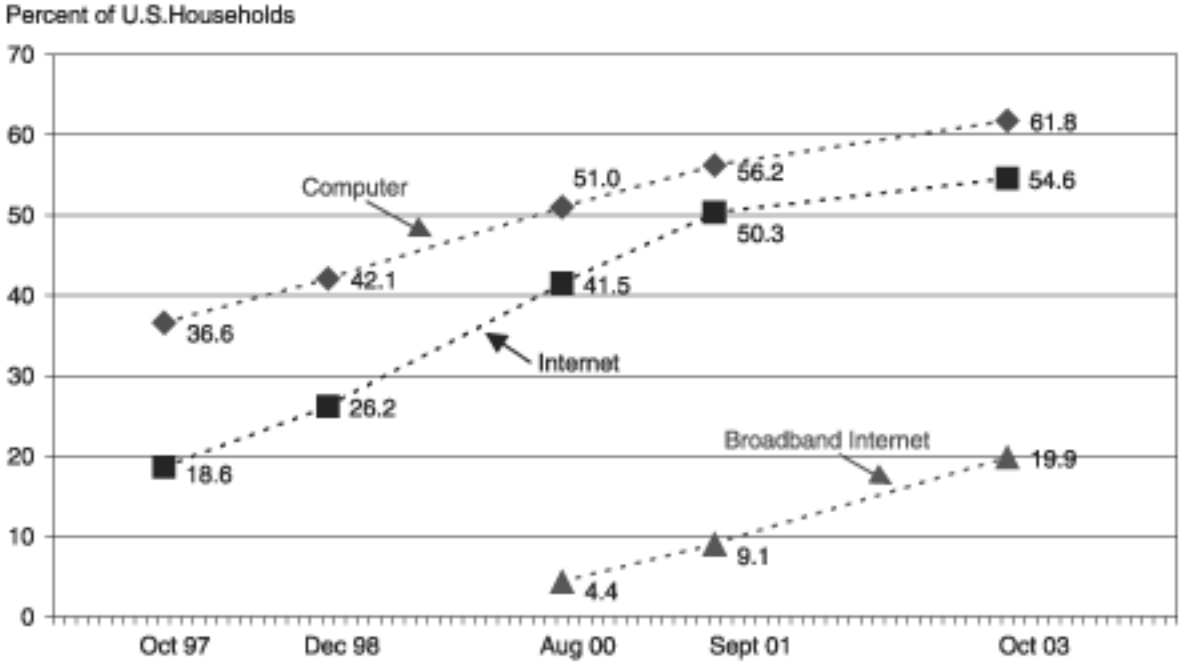
[83] This is an oversimplification of Cortada's thesis for the sake of brevity. See Cortada (2004).

[84] For example, see the discussion in Rosston (2006) or Paltridge (2006).

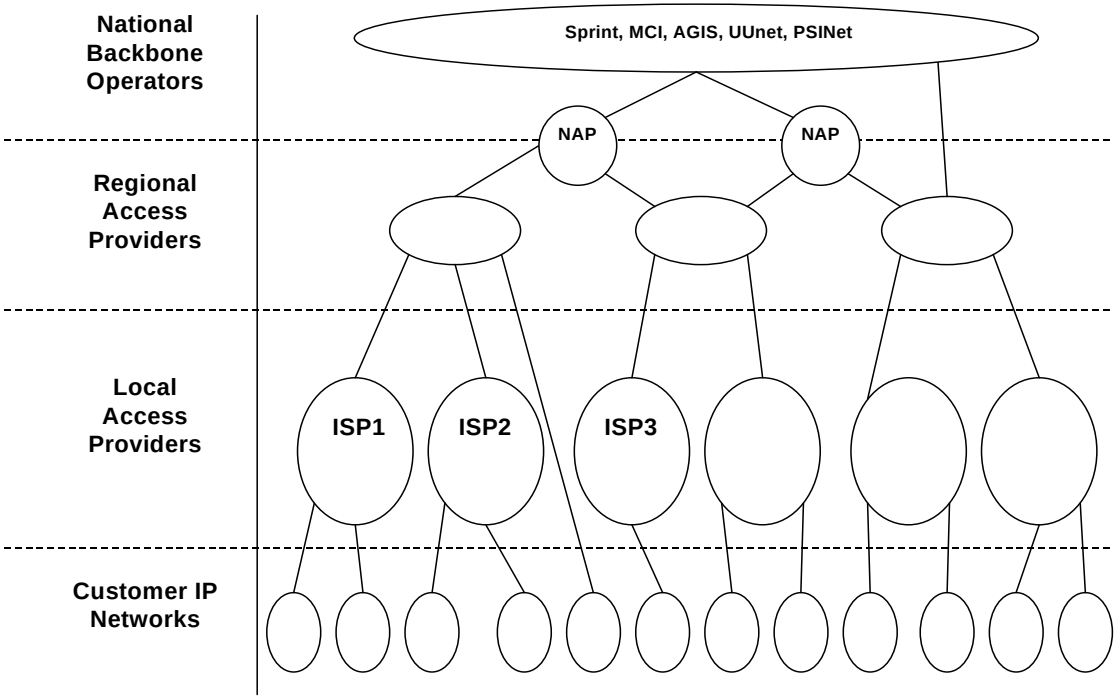
[85] This complex topic strays into matters outside the scope of this paper. For extensive description and analysis, see e.g., Mosier (2004), Bauer (2005) or Nuechterlein and Weiser (2005). Or, see the court ruling a year later at the Washington D.C. Circuit Court, which restricted the FCC's prior decisions regarding CLEC entry and UNE (unbundled network elements) cost-based rates. See *United States Telecom Association v. FCC*, 359 F. 3rd 554 (DC Circuit, 2004).

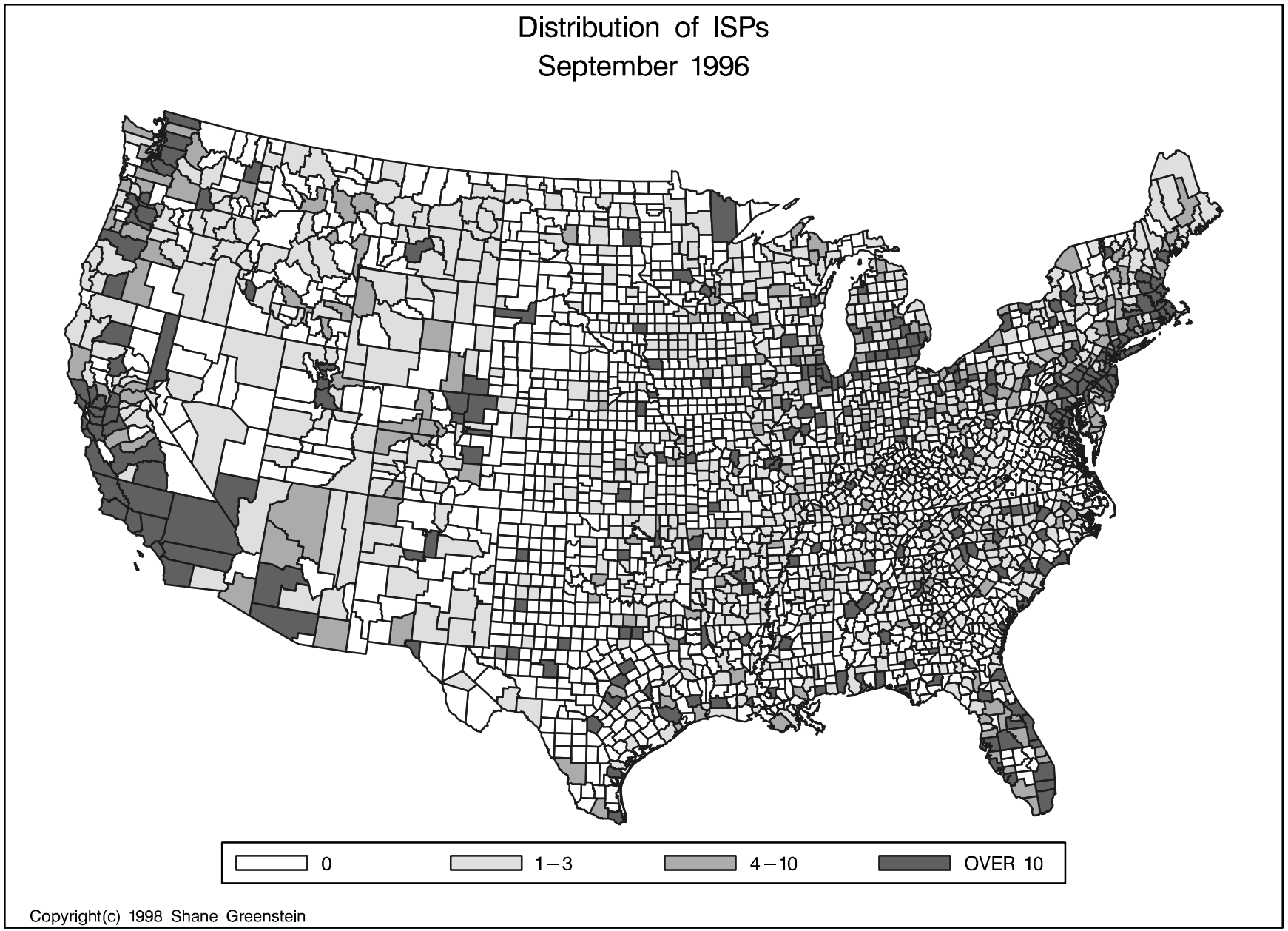
[86] For a list of the mergers among telecommunications carriers, and conditions placed on the final deals, see http://www.cybertelecom.org/broadband/Merger.htm.

Figure 1: Percent of Households with Computers and Internet Connections, Selected Years, 1997-2003*



*Note: 2001 and 2003 reflect 2000 Census-based weights and earlier years use 1990 Census-based weights.


National Backbone Operators
Sprint, MCI, AGIS, UUnet, PSINet
NAP
NAP
Regional Access Providers
Local Access Providers
ISP1
ISP2
ISP3
Customer IP Networks
Consumers and business customers


Distribution of ISPs
September 1996
0
1–3
4–10
OVER 10
Copyright(c) 1998 Shane Greenstein

Distribution of ISPs
October 1998